اقتصاديات التنقيب، الخطوات العملية لاكتشاف الزيت الخام والغاز الطبيعي

Economics of exploration: practical stages to discover crude oil and natural gas

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الملخص:

يسعى أي مشروع استكشافي إلى ايجاد رواسب هيدروكربونية جديدة بكميات كبيرة بسرعة وبتكلفة زهيدة. إن الاستثمار الأولي الذي يغطي استكشاف الحقل وتقييمه وتطويره لا يؤدي إلى تحقيق ربح على الفور. حقيقة أن الاستكشاف عادة ما يكون نشاطًا تجارياً تقوم به مؤسسات خاصة يعد أحد الاعتبارات الرئيسية عند التفكير في تقنيات الاستكشاف. احتمال الاكتشاف ضئيل للغاية. يعد اكتشاف المعادن صناعة عالية المخاطر، وبحسب مقولة شهيرة، لا تنجح إلا ثلاث مرات من كل ألف محاولة. وبالإضافة إلى ذلك، فإن التعدين في حد ذاته ليس مربحا. ولذلك، فإن التحدي الأول الذي يواجه العاملين في صناعة الاستكشاف هو إقناع الإدارة، وهو أمر سلبي للمخاطر، باعتماد ميزانية مناسبة من خلال تحديد إمكانات مشاريع الاستكشاف.

يستخدم قطاع البترول مجموعة متنوعة من تقنيات الاستكشاف والتقنيات وطرق المعالجة لاستخراج الزيت والغاز بشكل كامل. للوهلة الأولى، قد يكون اكتشاف مصدر بترولي أشبه بالبحث عن إبرة في كومة قش. ونظراً لتكلفة

1 – مدرس الاقتصاد بالمعهد العالي للعلوم الإدارية بأوسيم/ الجيزة.

المساعي الاستكشافية، فمن الواضح أنه سيتم بذل الكثير من الجهود لمنع الفشل.

يعتبر التنقيب عن الزيت والغاز صناعة خطيرة. تبحث شركات البترول عن مواقع ذات سمات جيولوجية معينة للتنقيب عن البترول من أجل تحديد نوع الحقل، وهو ما يعادل منطقة جغرافية متجاورة بها البترول. على سبيل المثال، من أجل احتجاز الهيدروكربونات، تبحث شركات البترول عن أماكن ذات هياكل جيولوجية (خاصة الصخور والتشوهات تحت السطح).

يتم إنشاء أنواع مختلفة من الخرائط باستخدام الكم الهائل من المعلومات والبيانات التي تم جمعها من المسوحات الجيولوجية والجيوفيزيائية العديدة والآبار الاستكشافية. يتم رسم الخطوط على فترات عمق منتظمة لإنشاء خرائط تعرض البنية الجيولوجية فيما يتعلق بعلامات الارتباط. وسيتم حفر المزيد من الآبار الاستكشافية واختبارها في حالة نجاح القط البري. ومن أجل معرفة أكبر قدر ممكن عن حجم المكمن، وكمية الهيدروكربونات الموجودة، وإمكانية إنتاج.

ونظراً للاستثمارات الرأسمالية الكبيرة، والمخاطر الفنية المتعلقة بتوافر التكنولوجيا ومهارات القوى العاملة، وكمية احتياطيات البترول المؤكدة، والسياسات المناخية للتنمية الاقتصادية منخفضة الكربون، والمخاطر السياسية، فإن أنشطة المنبع النفطية معرضة لمخاطر اقتصادية ومالية.

كلمات مفتاحية (تكنولوجيا التنقيب، الحفر الاستكشافي، الاستثمار في التنقيب)

Abstract

Any exploration project seeks to quickly and cheaply discover new hydrocarbon deposits with large quantities. An initial investment that covers the exploration, assessment, and development of a mine does not immediately result in a profit.

The fact that exploration is typically a commercial activity carried out by private enterprises is a key consideration when thinking about exploration technologies. The likelihood of discovery is quite slim. Mineral discovery is a high-risk industry that, according to a famous saying, only succeeds three times out of every thousand attempts. In addition, mining itself is not profitable. Therefore, the first challenge facing those working in the exploration industry is persuading the management, which is risk adverse, to authorize an appropriate budget by outlining the potential of exploration projects.

The oil and gas sectors use a variety of exploration techniques, technologies, and processing methods to fully extract oil and gas. At first glance, discovering a petroleum resource can like searching for a needle in a haystack. Given the expense of exploratory endeavors, it is obvious that much effort will be put forward to prevent failures.

Exploration for oil and gas is regarded to be a dangerous industry. Oil firms look for locations with particular geological features to drill for oil in order to identify an oil field, which equates to a contiguous geographic area having oil. For instance, in order to potentially trap hydrocarbons, oil corporations look for places with geological structures (particular rocks and subsurface contortions).

Different sorts of maps are created using the enormous amount of information and data gathered from the numerous geologic and geophysical surveys and exploratory wells. Lines are drawn at regular depth intervals to create contour maps, which display the geologic structure in relation to correlation markers.

More exploration wells will be drilled and tested if the wild cat is a success. In order to learn as much as possible about the reservoir volume, the quantity of hydrocarbons present, and the discovery's potential for production, it is decided how many and where to place these wells.

Keywords (exploration technologies, Exploratory Drilling, Investment in exploration)

Introduction

Exploratory drilling, geologic surveying, and geophysical surveying are the three main tasks involved in finding or discovering a petroleum resource. An overview of each of these initiatives can be found in the following sections. (Mohamed & A. Fahim, 2016, p. 6)

The choice of a drilling site is a difficult and expensive process. Many ancient oil fields were discovered by these occurrences, even though some visible evidence of a hydrocarbon source, such as seepage of oil and gas from the surface, the visual appearance of surface and vegetation, the presence of oil or gas in fountains or rivers, etc., is sometimes used to locate oil and gas reserves. However, these fortunate occurrences are now extremely uncommon and occasionally might not be suited for commercial use.

In addition to lowering production costs for unconventional oil, technological improvements over the past ten years have also made tight oil extraction more like a manufacturing process, where production can be changed in reaction to price fluctuations rather easily.

This stands in stark contrast to other extraction techniques (such offshore extraction), which have high upfront costs, lengthy lead times, and—more importantly—difficulty adjusting the quantity produced once a process is operating. Since US production can significantly contribute to balancing global demand and supply, one implication of the recent oil revolution1 is that the low oil price scenario may last for some time. (Mohaddes & Raissi, 2018, p. 1516)

The importance of this study stems from providing a full descriptive analysis of the Successive stages of finding oil and gas.

1.1. methodology

The adopted methodology consists of a review of previous related literature and empirical studies concerned with requirements and expectations for exploration technologies to find oil and gas. In addition, an in-depth analysis of development of Oil and Gas Fields.

1.2. background

Thousands of feet below the earth's surface and on the ocean, floor are reservoirs where oil and gas are stored. The geologic history of the world would determine where these reservoirs would exist. Thus, locating petroleum reserves is a tremendously complex task and is likely the most difficult component of the petroleum sector. (Li, Liu, Luo, & Wang, 2020) One of the main responsibilities of oil and gas businesses investing abroad is evaluating their investments, among which risk assessment and benefit assessment rank highest.

(O. Adeola, et al., 2021) Since its discovery in the middle of the 19th century, crude oil exploration has become an important source of income for Africa through commerce and investment. (Qiu, Wang, & Xue, 2015) Deepwater oil and gas projects carry significant risks related to engineering and geology, which have a significant impact on project valuation.

(Lei & Baosheng, 2008) An oligopoly corporation decides how much should be invested in its R&D in order to make the biggest profits, and it takes into account both what its rivals have done as well as how they might react to its activity.

(Okada, 2022) The mining industry must find more resources in the earth's crust to meet the demand for metals and/or raw materials because the need for mineral resources is increasing along with population increase, urbanization, and industrialization. On the other hand, under more difficult conditions and circumstances for mineral exploration, the finding rate of new ore deposits, notably from greenfield exploration, has continued to decline during the recent years.

(Cavalcanti, Da Mata, & Toscani, 2019) demonstrates the causal relationship between oil discoveries and local growth. The findings demonstrate that oil finds have positive spillover effects and greatly improve local output.

(Seyyedattar, Zendehboudi, & Butt, 2019) The development of offshore oil and gas reserves, which make up a sizable fraction of the global reserve base, is anticipated to assist close a potential hydrocarbon supply deficit in the near future. The oil and gas sector has been able to expand exploration and production operations into deeper and ultra-deeper waters and harsher settings thanks to ongoing technological advancements.

(Tafur, Lilford, & F. Aguilera, 2022) Due to significant capital investments, technical risks related to the availability of technology and workforce skills, the quantity of proven oil reserves, climate policies for low-carbon economic development, and political risks, upstream oil activities are subject to economic and financial risks.

This paper combines many aspects like Requirements and expectations for exploration technologies, Exploratory Drilling, Development of Oil and Gas Fields, and Investment in exploration.

1. Requirements and expectations for exploration technologies

Technologies are essential to resource discovery as well as resource extraction as a way to protect rare resources. Fewer reserves, from the standpoint of resource economics, may make another extraction unit more expensive in addition to not being able to satisfy a particular demand. In order to make extraction more affordable, it is required to spend an excessive number of resources on exploratory activities. However, exploration alone cannot keep extraction costs low since, as more new information is discovered, exploration may become more expensive. Therefore, a technological advance is necessary to find a solution to this problem.

The development of two technologies is seen by many nations as crucial policy action. The first is a rise in extraction efficiency, which reduces the given extraction cost for the remaining reserves, and the second is an increase in exploration efficiency, which boosts exploration productivity given the cost that has already been determined. (Sawada & Managi, 2014, p. 1:2)

Any exploration project seeks to quickly and cheaply discover new hydrocarbon deposits with large quantities. Budgets for exploration and opportunities for acquisition are directly competitive. There is no incentive to continue exploration if a business spends more money finding oil than it would to buy the same amount "in the market place." In contrast, a business that is successful in discovering new reserves at a cheap cost enjoys a major competitive advantage since it can fund more exploration, locate and develop reservoirs more profitably, and target and expand fewer possibilities.

2.1. Mining-specific risks and the role of exploration

Apart from the intrinsic risk associated with the mining sector, which is that the natural resources that underlie its wealth are limited, non-renewable, and may eventually run out, the key hazards unique to the mining sector in comparison to other business sectors are as follows:

(1) Since the position of the mineral deposit itself determines both the company base's location and other locational factors, there is essentially little room for choice.

(2) Dealing with nature's uncertainties, eventualities, and unanticipated changes in the natural world is required.

(3) Mineral exploration is very unsuccessfully.

(4) An initial investment in the exploration, assessment, and development of a mine does not immediately result in a profit.

(5) In comparison to other business sectors, mining projects often require a somewhat long lead-time. This characteristic amplifies the effect of uncertainty.

(6) Due to the uneven distribution of mineral resources throughout the world, every country must, to a greater or lesser

extent, rely on imports for some commodities. This implies that country risk affects the mining business.

(7) There are disparities in state systems overseeing the mining industry due to geography, religion, or culture.

(8) Mining developments might potentially leave a huge environmental footprint.

The first two risks—unable to select a site and uncertain natural phenomena—are the greatest, and it can be claimed that the remaining risks are brought on by or connected to these first two hazards. It goes without saying that successful exploration is a prerequisite for mine development, but exploration's importance should extend farther than that.

Exploration should assist in lowering the risks at each succeeding stage of the mining cycle—from feasibility study through development, production, closure, and rehabilitation—after the finding of the mineral deposit. From the mine development to the mine operation stages, exploration should provide information about the amount and grade of ore to guarantee the development and operation of the mine as expected. At the feasibility study stage, exploration should provide information for the criteria to evaluate whether or not the deposit can generate economic value.

Obtaining extra ore volume within and around the deposit is also crucial. The purpose of mineral exploration in the mining industry is to lower risk at each stage of the mining cycle and serve as the entry point into the mining cycle. (Okada, 2022, p. 430)

2.2. Characteristics of exploration technologies

The technological environment includes changes to businesses' outputs, production processes, equipment usage, and product quality. It involves technological advancements in production brought about by scientific advances. By reducing energy use, environmental degradation, and harm, advancements in technology have fundamentally changed the competitive environment of the oil and gas business.

Technology improves equipment failure or leak detection as well as exploration, mapping, and identification of petroleum resources beneath the earth's surface. In order to fit the demands of a changing environment, businesses can use technology to adapt, integrate, and reconfigure internal and external organizational skills, resources, and functional competence. (Goodheart Akhimien & Ayo Adekunle, 2023, p. 3:4)

The fact that exploration is typically a commercial activity carried out by private enterprises is a key consideration when thinking about exploration technologies. The likelihood of discovery is quite slim. Mineral discovery is a high-risk industry that, according to a famous saying, only succeeds three times out of every thousand attempts.

In addition, mining itself is not profitable. Therefore, the first challenge facing those working in the exploration industry is persuading the management, which is risk adverse, to authorize an appropriate budget by outlining the potential of exploration projects.

In that they are planned and carried out based on numerous working assumptions, the sequence of procedures in mineral exploration has many similarities with research activities, such as those in the natural sciences. However, because it is a commercial activity, mineral exploration is significantly different from scientific work.

Finding ore deposits is the goal of mineral exploration; refuting the working hypothesis is not. As a result, whether or not an ore deposit is found during a survey based on a working hypothesis, it is likely that the accuracy or falsity of the pertinent working hypothesis was not completely verified.

Similar to investment decisions in general business, mineral exploration decision-making frequently requires a leap of faith despite being grounded on scientific knowledge and experience. Simply put, mineral exploration is a great illustration of the adage "You never know unless you try."

The fact that mineral deposits can never be discovered without drilling, which is exceedingly expensive in comparison to other exploration techniques, is a significant factor to take into account. Drilling arbitrarily and blindly is difficult, yet drilling the entire target area in great detail to completely comprehend the mineral deposit is also unrealistic.

Therefore, in order to successfully conduct exploration within the financial constraints, exploration engineers devote as much money as feasible to drilling. They construct a drilling program to drill as many holes as possible in a desirable location and, if possible, choose less expensive drilling techniques.

Based on the aforementioned, cost-effectiveness is more significant than other technical aspects in research on exploration technology, and economic rationality is severely necessary. No matter how advanced the technology, if it has a high operational cost, it won't be used in real-world applications. In this regard, technological advancement and the adoption of new technologies are fairly conservative in the mining sector.

Additionally, innovation frequently takes precedence over invention in studies on exploration technology. In general, technological innovation refers to the development of better, procedures that are accepted by the markets, or better goods. Innovation varies from invention in that it refers to a significant improvement of something that already exists and is, by definition, less risky. Invention denotes the first creation of something new.

The fact that many different cutting-edge exploration technologies are frequently offered as a service by contractors that use such technologies to conduct mineral exploration for the clients is another crucial aspect to take into account when thinking about exploration technology.

The findings of research conducted utilizing those technologies are frequently kept by the clients in the strictest confidence and are rarely shared with the contractors. As a result, there aren't many possibilities for the contractors—the creators and/or users of advanced exploration technologies—to gain knowledge from the outcomes of their implementation.

Because of the aforementioned factors affecting exploration technology, many effective exploration engineers, particularly geologists, have a tendency to be cautious or doubtful about purportedly high-tech exploration techniques, such as geophysical techniques. The following are symbols used by David Lowell (2014) to represent these inclinations:

Geophysical surveys and high-tech equipment are hardly ever useful in the search for new mines. The successful explorer and the rocks should have an almost metaphysical conversation in which the rocks speak to the explorer. He may impress uniformed management if he delegates some of this geological mapping work to a high-tech device, but he is less likely to discover a mine.

Of course, Lowell's opinion is supported by both his extensive expertise and factual statistical information. A typical sample of base-metal and precious metal deposits, including 38 gold, 14 copper, 1 silver, and 1 zinc deposit in the circum-Pacific region identified over a quarter-century from 1970 to 1995, were examined by Sillitoe (1995).

Sillitoe (1995) came to the conclusion that geological work had been the most effective discovery methodology and that geophysics had played a limited role in successful exploration, with only seven (13%) of the deposits under evaluation having a geophysical contribution to their discoveries.

However, the environment in which exploration technology is used is evolving. By examining case studies from 14 additional deposits found in the late 1990s, Sillitoe (2000) updated his earlier review (Sillitoe 1995) previously mentioned. He came to the conclusion that the use of geophysics, which was crucial in 43% of the reviewed case histories, represented the most notable change in the discovery process since 1993.

Sillitoe (2010) asserts that ten years later, geophysical exploration is still contributing at the same level. Nine out of the 13 deposits where geophysics helped with the finding process are actually revealed and not disguised, therefore the contribution of geophysical investigation is not always because the subject was a "geologically blind" concealed deposit.

The geophysical techniques used seem to have been carefully chosen for the types of mineralization involved, and the outcomes were then successfully incorporated into the supporting geological and geochemical conceptual model (Sillitoe 2010). (Okada, 2022, pp. 430-431)

2.3. Methods and Techniques to find oil and gas

However, modern technology and engineering have significantly improved the performance and safety of crude oil exploration today, according to the United Nations Environmental Program (UNEP 1997). The fundamental exploration techniques still used today are the same as those used in the early scientific oil exploration of 1912 that led to the discovery of Cushing Field in Oklahoma, USA. The oil and gas sectors use a variety of exploration techniques, technologies, and processing methods to fully extract oil and gas. (O. Adeola, et al., 2021, p. 33)

Geophysical, geochemical, and geotechnical techniques are used in contemporary exploration approaches. Exploration of the Earth's surface can help to image or map subsurface formations that are conducive to the buildup of oil and gas.

Gravimetric, magneto metric, seismic, radioactive, and stratigraphic surface investigations are collected using geophysical methods.

Geochemical techniques are used to analyze the rocks and soil at the surface for chemical composition. Measurements are made using geotechnical techniques, like the mechanical characteristics of rocks and surfaces. The most recent innovation in low-cost geological survey is remote sensing from satellites.

Seismic, magneto metric, and gravimetric techniques are common geophysical techniques. The cuttings (rock samples cut by the drilling bit) and core (a short column of rock removed from the wall of a drilled hole) of the drilled site are chemically analyzed using geochemical procedures. (Chaudhuri, 2011, p. 9)

At first glance, discovering a petroleum resource can like searching for a needle in a haystack. Given the expense of exploratory endeavors, it is obvious that much effort will be put forward to prevent failures. To analyze a potential area, a number of disciplines are used, including geology, geophysics, mathematics, and geochemistry.

However, only around one in three exploratory wells will find significant volumes of hydrocarbons on average, even in well-developed regions where exploration has been occurring for years. (Ebrahim, 2018, pp. 28-29)

2.3.1. Geophysical exploration

Geophysical exploration requires advanced technologies. Few businesses globally are capable of doing research, producing equipment, and offering technology services to oil-field corporations. Three businesses currently control a majority of the global geophysical exploration industry: Western Geophysical, which is owned by Baker Hughes, GecoPrakla, which is owned by Schlumberger, and Compagnie Générale de Géophysique (CGG), which holds a market share of more than 75%.

Numerous services are offered by Prakla and CGG, ranging from research and the production of geophysical exploration equipment through the acquisition, processing, and analysis of seismic data. The software market for geophysical exploration is dominated by Schlumberger-owned Geoquest and Halliburton-owned Landmark. (Lei & Baosheng, 2008, p. 191)

2.3.2. Seismic survey

Seismic surveying has developed into one of the best strategies for enhancing field output. It is utilized in (Ebrahim, 2018, p. 30)

• identifying structural and stratigraphic traps through exploration

• determining where to drill the first wells

• estimating reserves and creating field development plans through field appraisal and development

• production to monitor reservoir activity, such as tracking how reservoir fluids respond to production

The use of sound by marine mammals in the water is becoming more and more competitive with noise produced by humans. The health and welfare of the animals are at risk as a result. One significant anthropogenic cause of this noise is hydrocarbon prospecting. The evaluation of policy alternatives aimed at decreasing noise pollution damages is complicated by the lack of information regarding the possibility of hydrocarbons and the harm to marine life.

Because hydrocarbon companies and national treasuries have mutually beneficial interests, the search for new oil and gas sources has expanded into more hazardous offshore marine areas. Following from long-term successes in onshore Arctic habitats like the Alaskan North Slope and offshore near-Arctic environments like the Norwegian Sea, these interests have led to expanding exploration-lease offerings throughout the Arctic region.

While the specifics of offshore exploration licenses can vary, they typically involve an auction process that results in a term-limited exclusive lease right, and responsibility, to engage in exploratory activities intended to see if it is feasible and worthwhile to move into production activities.

The alternative of an initial investment by a leaseholder in less expensive seismic surveys may be appealing given that exploratory drilling for oil in Arctic offshore settings is expensive and getting more so. Companies looking for hydrocarbons can choose not to drill at all, to carry out seismic surveys (henceforth surveys), which provide better information about the net asset value of the possible resource, or to forego surveys completely and conduct exploratory drilling.

The firms' rising expenses are principally caused by greater ambiguity over the existence of hydrocarbon reserves, and unrestricted surveying decisions will depend on the possibility of boosting earnings by lowering this uncertainty. (J. Punt, & A. Kaiser, 2012)

Establishing the relationship between seismic reflections and stratigraphy is one of the key tasks in seismic data interpretation. It is possible to create a synthetic seismogram that represents the anticipated seismic response from some wells' acoustic and density logs, at least over the intervals of commercial interest, and compare it to actual seismic data.

Additionally, some wells offer Vertical Seismic Profiling (VSP) data, which can provide a more precise connection between well and seismic data. VSP data is obtained by blasting a surface seismic source into a downhole geophone. (Abuzaied, Metwally, Mabrouk, Khalil, & Ali Bakr, 2019, p. 105)

2.3.3. Geologic Survey

The oldest and most widely utilized method for locating prospective subterranean petroleum deposits is geologic surveying. Surface rock samples, formation outcrops, and geological surface analysis are all part of the process.

Using the gathered data in conjunction with geologic theories, it is possible to evaluate whether there are any potential petroleum resources nearby. The geologic survey's findings are tentative and only hint at the prospect of discovering petroleum resources. (Mohamed & A. Fahim, 2016, p. 7)

2.3.4. gravity survey

The gravity survey is the most affordable technique for identifying potential petroleum reservoirs. It includes the use of a gravimeter, a device that detects a reflection of the density of the rock below the surface. For instance, the gravimeter can identify salt domes, which would suggest the presence of an anticline structure, because salt is less dense than rocks. A structure like that is a contender for potential gas and oil buildup. (Ebrahim, 2018, p. 41)

Only in primary (reconnaissance) surveys, where little is known about the subsurface geology and/or the thickness of potential-interesting sediments, are magnetic and gravity methods used. (O. Adeola, et al., 2021, p. 34)

2.3.5. magnetic survey

The kind and depth of the subsurface rocks have an impact on the magnetic pull, which is measured during the magnetic survey. The presence and depth of basement rocks, or subterranean volcanic formations, that have significant magnetite concentrations can be ascertained using the magnetic survey. These details are used to determine whether there are any sedimentary formations atop the basement rocks. (Ebrahim, 2018, p. 41)

2.3.6. Remote sensing

A contemporary method called remote sensing uses infrared, heat-sensitive color photography to find water, faults, and other structural features beneath the earth's surface. Normally mounted on a satellite, the sensing equipment transmits data to specialized computers, which then create maps of the subsurface structures. (Mohamed & A. Fahim, 2016, pp. 7-8)

The creation of remote sensing equipment like side looking aerial radar (SLAR) made it easier to observe surface features in order to learn more about the subsurface. This technique enabled the continued use of surface observation-based exploratory approaches and is still employed as an additional tool in the search for hydrocarbons. It does this by showing faults, signs of anticlines, and other features. (M. Jones, 2017, p. 132)

2.4. prospect appraisal

Quantitative estimations of the potential quantities of oil and/or gas in an undrilled prospect, trap, average block, or basin are frequently developed in a contemporary exploration project using the findings of in-depth investigations and research. These projections help individuals in charge of making investment decisions determine a venture's likelihood of success and the potential rewards that could result from it.

Quantitative prospect appraisal has long piqued geologists' interest due to the extremely high sums of money associated with exploration investment decisions. There are many various techniques that have been created, ranging from straightforward subjective estimation approaches to extremely complex computer models. Any strategy that even slightly enhances the investor's risk assessment is extremely important.

The quantity and caliber of the available exploration data, however, affects the choice of estimation methodology. When only basic geological data is available, prospect evaluation may be based on straightforward geological models that take trap sizes and the size of probable oil- and gas-producing areas into account. Such techniques can produce trustworthy results in the hands of experts.

Shell geologists have created an appraisal approach based on a computer model that mimics the subsurface processes of oil and gas creation, migration, accumulation, and retention for situations where more detailed geological information is available. The main model steps are summarized in the following figure. (W. Pearce, Siebert, & Walter, 1984, p. 82)

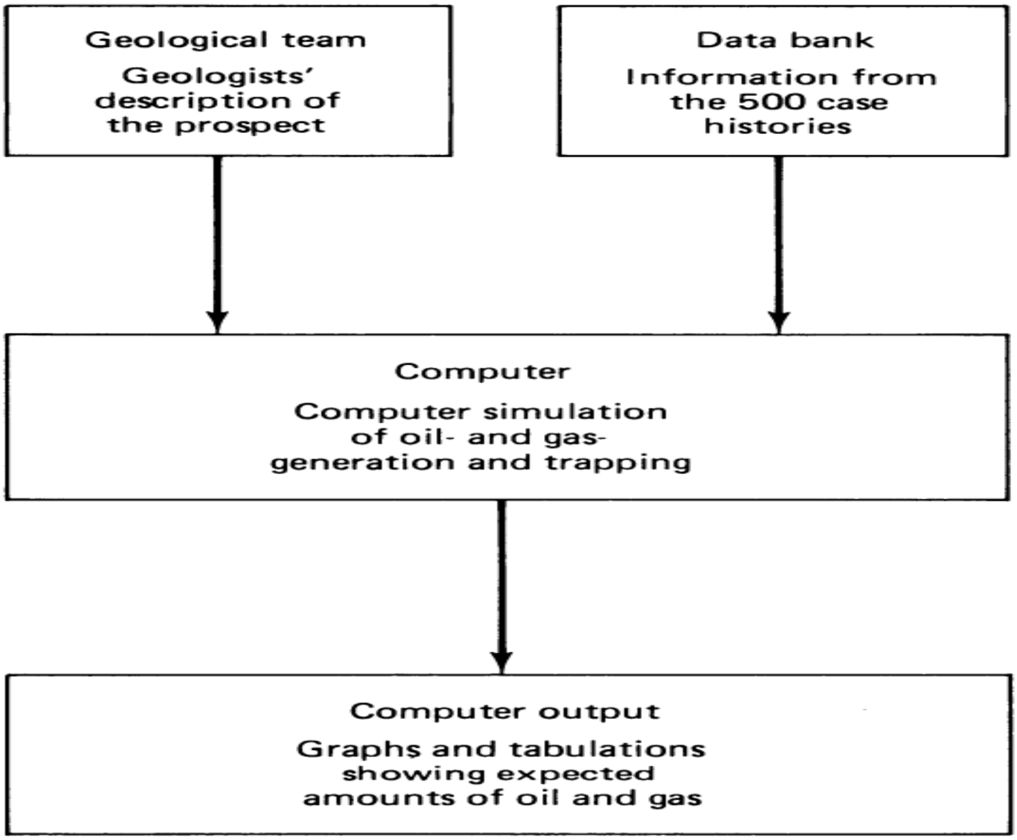

Figure 1: Computer model of oil and gas generation (W. Pearce, Siebert, & Walter, 1984, p. 83)

The model is based on a very large data set that includes case studies of more than 500 well-documented oil and gas fields as well as decisively tested dry traps from exploratory projects that Shell geologists throughout the world have either operated or researched. The geologists and geophysicists are obliged to submit the findings of their technical study in the form of judgements relating to the formation of petroleum and its migration and retention in the trap in order to evaluate a particular prospect.

2. Exploratory Drilling

Due to the unknown pressure zones during exploration drilling, conservative mud weight procedures, casing design, and penetration rates are used. As a result, wells are frequently slow and expensive. Additionally, unless bypass and sidetracks are necessary, exploration wells are usually always dug vertically straight down to the target.

If exploration is unsuccessful, sidetracks may be drilled before abandonment to learn more about the geology of the formation, which raises the well's cost. Since there are no restrictions on land or infrastructure offshore, the majority of successful exploration wells eventually become producer (development) wells.

This is far less common onshore. Delineation drilling frequently involves coring, fluid sampling, drill stem tests, and other procedures, which raises the expense of drilling. (J. Kaiser, 2021, p. 1258)

Location (onshore or offshore), well function (exploration, delineation, development), trajectory (vertical, directional, horizontal), borehole size and complexity (two-dimensional, three-dimensional, extended reach), type (original, sidetrack), measured depth, drilling program (sequence, batch, number of wells drilled), formations encountered, rig type (MODU, platform), mark, and other factors all affect drilling cost. (J. Kaiser, 2021, pp. 1260-1261)

Exploration for oil and gas is regarded to be a dangerous industry. Oil firms look for locations with particular geological features to drill for oil in order to identify an oil field, which equates to a contiguous geographic area having oil. For instance, in order to potentially trap hydrocarbons, oil corporations look for places with geological structures (particular rocks and subsurface contortions).

Geology and allied fields can help determine where to look for oil traps, and petroleum exploration includes estimation of the likelihood of discovery before drilling. However, the firm cannot be convinced that hydrocarbon resources actually exist without drilling. Even with contemporary technology, drilling a well is the only surefire way to verify the oil presence hypothesis. Oil firms may spend a lot of money gathering data, yet never make any discoveries—let alone ones that are profitable.

Even in locations with the proper geological qualities, the likelihood of discovering oil through drilling might be minimal, so learning from experience is a crucial part of the petroleum industry. Drilling tests are expensive and may not eliminate the doubt about the presence of oil.

Subjective probabilities are commonly recognized in the petroleum sector, although the odds of successfully drilling for oil in a freshly investigated location might be very low. Drilling is not a "safe bet," even with contemporary technology, because there is no assurance that a corporation will discover oil after drilling. Oil finding depends on both geological properties and "luck" because of the peculiarities of drilling. (Cavalcanti, Da Mata, & Toscani, 2019, p. 89)

It is possible to define and realize the geologic structure that may hold oil or gas using the information gathered from geologic and geophysical studies. However, we still need to ascertain whether petroleum is present in these geologic traps and, if so, whether it is there in sufficient quantities to make the exploitation of the oil/gas field profitable. Exploratory wells must be drilled and tested in order to produce a definitive response.

The geologists and geophysicists choose the location for drilling the exploratory well, sometimes referred to as the wildcat well. The nature of the various rock layers that will be drilled, as well as the fluids and pressures that may exist in the various formations, are unknowns at the time the well is being drilled.

In order to assure the operation's safety, the well completion and drilling program are typically overdesigned. As a result, this first well is not the best design and would likely be much more expensive than the other wells that would be drilled in the area.

The chemistry and fluid content of samples of the rock cuttings collected during the drilling of this exploratory well are analyzed. The information is used to determine the kind of formation relative to depth and to determine whether there are hydrocarbon elements present in the rock. Also gathered, stored, and transported to specialized labs for analysis are formations cores.

Every time a well is dug into a petroleum-bearing deposit, the well is tested while it is put on controlled production. Various logs are taken both after the well has been drilled and occasionally throughout the drilling process. Electric, radioactive, and acoustic logging instruments and techniques are among of the methods utilized to record information about the drilled formations.

The measured signals from these instruments are relayed to the surface and stored on computers as they are lowered into the well on a wireline (electric cable). The signals are decoded and translated into depth-dependent rock and fluid parameters.

Important information on rock and fluid properties, fluid type and saturation, starting reservoir pressure, reservoir productivity, and other factors will be provided by the exploratory well. These are crucial and critical pieces of information that the field needs to advance. However, the majority of the time, the exploratory well's data won't be enough.

It could be necessary to drill additional wells to better define the dimensions and properties of the new reservoir. Naturally, not all exploratory wells will yield a discovery. Exploratory wells may encounter dry holes or reveal that the reservoir is not a viable development. (Mohamed & A. Fahim, 2016, p. 8)

Drilling of the first single wells into the crystalline basement's rocks to depths of 200–500 m and deeper can only begin if the promising zones have been identified preliminary. The coring must be strictly under the control of sampling, which was regrettably not done in the earlier works. To evaluate the basement's potential for oil and gas, though, this must be done right away. (Skvortsov, 2020, p. 305)

3. Development of Oil and Gas Fields

The amount of energy available to force oil from the reservoir rock into the wells determines how successfully an oil field will operate. There are three energy sources, however their potency varies greatly:

1. Water can push oil out of the reservoir rock and into the wells if the oil reservoir has a natural link to it, like in a typical anticline. This "water drive" can effectively pump as much as 60% of the initial oil into the wells.
2. The operator can only find the casing holes in the oil-saturated zone if there is originally a distinct concentration of natural gas above the oil. The gas cap expands to dispense oil as it is created, but only approximately 40% of the oil is recovered in the process.

In the beginning, some natural gas is dissolved in the oil in the majority of oil reservoirs. Gas bubbles that break from the oil when the oil field is created push the oil in the direction of the wells. Less than 20% of the oil is typically recovered. (D E F F E Y E S, 2001, p. 105)

There are significant advantages to planning the oil field's full existence as soon as it is discovered. As part of the strategy for drilling the initial production wells, petroleum engineers can identify gas and water injection wells. Instead of aiming to maximize the early cash flow, the program might be optimized for total oil recovery. When designing the field, "what if" scenarios might be tested using computer simulations.

Simple computer simulations, however, can be seriously misleading. For a hypothetical "homogeneous isotropic" reservoir with no natural water drive, the computer problem is not particularly challenging for a natural gas reservoir. Real reservoir rocks are highly structured internally.

For instance, even tiny, 1/4-inch-thick mudstone streaks have a significant impact on fluid movement. The quantity of gas, oil, and water present has a significant impact on the rate at which they flow. John von Neumann recognized weather forecasting and oil reservoirs as significant issues requiring enormous quantities of computing capacity at the very dawn of the modern computer age. (D E F F E Y E S, 2001, p. 106)

Large size could, in a number of ways, boost the likelihood of discovery. We begin with the presumption that every oil field has a distinctive length. The term "length" is merely a generalization that can refer to the width, thickness, or length of the oil field. Here are some instances where "length" may be relevant:

1. The "length" cubed (length times width times thickness) determines an oil field's volume. Large oil fields may spill enough oil to the surface to draw a large number of drillers.

2. The square of "length" (length times width) determines the area. Essentially, this is Menard's model. You are more likely to strike an area on a map when you toss a dart if it is larger.
3. In relation to "length" (length raised to the power one), the diameter is similar. As an illustration, suppose I start my exploration drill over what I believe to be an oil field. If, however, my position is off by more than the oil field's diameter, it will be dry hole time.
4. When "length" is multiplied by a power of zero, the result is 1.

Consider the scenario where I travel to Iran and hammer a surveyor's stake into the top of each of the discernible surface anthills. I place a tiny dot, a mathematical point without length, width, or thickness, on top of each stake. The dot's diameter is equal to the zero power of "length." I randomly select names from a hat after writing the names of the anticlines on slips of paper. (D E F F E Y E S, 2001, pp. 114-115)

Different sorts of maps are created using the enormous amount of information and data gathered from the numerous geologic and geophysical surveys and exploratory wells. Lines are drawn at regular depth intervals to create contour maps, which display the geologic structure in relation to correlation markers. Isopach maps show how the correlation markers' varying thicknesses vary.

There are also produced other significant maps, such as porosity maps, permeability maps, and maps displaying differences in rock properties and structural configurations. Conceptual models depicting the specifics of the structure and the position of the oil and gas within the structure are developed using all available data and formation maps.

To determine the petroleum reserves and to decide and prepare for the development of the field for commercial operation, the data currently available will be sufficient.

Petroleum field development requires the combined, integrated efforts, and expertise of several professions. In order to define, describe, and characterize the reservoir, geologists and geophysicists are required. Engineers of reservoirs decide how to produce petroleum reserves and maintain the reservoir over the course of a field.

Drilling engineers develop the well drilling programs based on the well completion design, while production and completion engineers construct the well completions and production facilities to manage the various production methods and conditions.

Each group used to work independently and present its output to the following group in the past. In other words, the reservoir engineering team receives the finished product from the geologists and geophysicists when they have finished their work.

The output of reservoir engineering would then be given to production engineering, and so forth. Each group had to revisit the previous group virtually always to ask questions, get clarifications, or assign more work. It has been determined that this is an extremely ineffective operation.

The majority of significant businesses have recently embraced the so-called multidisciplinary team approach to field developments. This method involves assembling a team of engineers and scientists from all relevant fields. Throughout the field development stage, the team members collaborate as a single unit.

Of course, the team collaborates closely with other professionals like computer scientists, planners, cost engineers, economists, and so forth, and they may even become permanent members. Experience has proven that this field growth strategy is incredibly effective, and more and more businesses are following suit.

The duties and responsibilities of drilling, reservoir, and production engineering are briefly described in the sections that follow. (Mohamed & A. Fahim, 2016, pp. 13-14)

Exploration activities are the first step in the development of an oil and gas field. The location of a probable hydrocarbon reservoir is identified using geological and geophysical surveys and research.

The findings of these studies just offer data regarding the reservoir's possible location, size, depth, and some characteristics like faults and fracturing. A spot (often at the center of the probable reservoir) is chosen to drill the first exploratory well, known as wild cat, based on the information at hand.

Since no data are yet available for proper well design, this well's design is based on experience. Data on the rock and fluid characteristics of all penetrated formations are being gathered and analyzed as this well is being drilled.

Through the target depth of the potential reservoir, more consideration is given, more data are gathered, and more information is examined. If hydrocarbons (oil and/or gas) are discovered, the well is examined to assess its capacity for production; if not, it is regarded as a dry well and abandoned.

More exploration wells will be drilled and tested if the wild cat is a success. In order to learn as much as possible about the reservoir volume, the quantity of hydrocarbons present, and the discovery's potential for production, it is decided how many and where to place these wells. At this point, preliminary reservoir simulation studies and economic assessments are undertaken to ascertain whether the discovery is commercially viable.

Extensive simulation studies will be carried out to explore potential development and production methods after the decision to develop the field has been made, with the aim of identifying the ideal development and production plan that yields the greatest recovery and best economics.

After that, plans for well completion will be created with the intention of having wells operate throughout the duration of the field, giving optimum recovery in the most practical and secure way. The well drilling designs and programs will be created based on the completion plans.

The surface facilities for the separation and treatment of produced fluids are currently being designed depending on the production prediction. Materials and equipment are planned for and made available on time for actual field development and production through careful planning and procurement.

Then, drilling activities begin on schedule. Each drilled well is examined and assessed, and the drilling program may be changed as a result of the information gathered. All or a portion of the surface production and processing plant should be present to produce wells as they are being drilled and finished in order to increase income.

Production data, including rates of production, pressures, temperatures, the gas-to-oil ratio, and any water cut, are gathered over a period of time and then contrasted with anticipated (predicted) data derived from reservoir models. No match would typically be made. The reservoir simulations are then altered (by changing the data used to produce the original simulations that have the least certainty) through a process known as history matching until the simulation data match the real production data. Future production forecasts are then made using the adjusted simulations.

Once more, after some time has passed, the recent simulation data are contrasted with the actual production data. Once more, there would be no match. Repeating the history matching procedure would probably go on till the field's life was up.

It should be noted that several procedures, including pressure maintenance, enhanced/improved recovery, and artificial lift, may be used throughout the field's production life. The field is abandoned after no more hydrocarbons can be produced economically.

Wells must first be sealed off, then layers of cement and sand must be added, and finally the surface casing must be covered. Regulations issued by the corporation or the government control this procedure. (Mohamed & A. Fahim, 2016, pp. 5-6)

4.1. **future prospects of development of offshore petroleum reservoirs**

Offshore developments continue to be a major contributor to the reserve base for the supply of hydrocarbons in the future, despite the lower level of offshore project approvals in response to the low oil prices of the 2014–2017 period. According to long-term predictions, offshore production might reach nearly 50% of the additional needs for oil and gas in 2025.

This trend has already begun, as seen by the more projects that were approved in 2018 than in 2016 and 2017. In fact, despite the recent slowdown, offshore output around the world continued to rise consistently since 2013.

This surge might be attributed to the approval of numerous offshore development projects starting in 2009, when oil prices spiked to well than 125 USD per barrel and held steady until 2014. Offshore field developments take longer than onshore field developments to attain commercial production before the building of infrastructure is finished in the first few years.

Because of this, offshore production increased even after 2013 as previously approved development projects moved closer to production. Based on this dynamic relationship between investment and production, it is predicted that offshore production would reach its peak in 2020, then begin to drop in 2021 and 2022 as a result of lower investments between 2014 and 2017. Because of present and projected increases in investments in an era of more stable oil prices, production levels in the offshore industry are anticipated to climb once more after 2022.

The offshore industry has gained invaluable experience in efficiency-focused and cost-compression practices in field development projects over the past few years of oil price decline by streamlining processes, standardizing and using modular designs, and utilizing cutting-edge and contemporary technologies. By reducing the time between project approval and the first oil, improved operational efficiencies can increase project economics and make offshore projects even more competitive with onshore developments in light of a projected future supply deficit.

With shorter payback periods of 3 years and 1.5 years for deepwater and shallow-water projects, respectively, compared to the pre-2014 high-oil-price environment, the average breakeven prices have been lowered to about 45 USD per barrel for deepwater projects and about 30 USD per barrel for shallow-water developments.

Deepwater reservoirs can be promoted as the largest source of supply growth over the next ten years by lowering the costs of deepwater developments through improved equipment and project design, new forms of industry collaboration, supplier alliances, and shared values between operating companies and host governments.

The increase and efficiency of offshore oil and gas field improvements are primarily made possible by technological advancements. (Seyyedattar, Zendehboudi, & Butt, 2019, pp. 2177-2179)

Given that a sizable amount of the world's energy potential comes from offshore oil and gas resources, deepwater petroleum investment has received a lot of attention. Deepwater oil and gas production projects do, however, carry a larger geology and engineering risk than onshore or continental shelf projects because of the maritime geographical context.

The total amount of investment and the complexity of the decision-making process both rise as a result of this circumstance. On the one hand, the fluctuation in the price of oil gives deepwater projects greater flexibility because they need more time for exploration.

On the other hand, deepwater projects are more technically risky to develop than onshore or continental shelf projects, and the value of deepwater projects is more significantly impacted by engineering and technological uncertainty. Since the value of flexibility from the uncertainties in oil price, engineering, and technology cannot be measured under the rigid assumptions, the traditional theory of net present value is unable to provide a sufficient reliable reference for the decision-making of deepwater oil and gas investment. As a result, the real options method based on uncertainty analysis is better suited than the traditional ones to analyze deepwater oil and gas projects. (Qiu, Wang, & Xue, 2015, p. 525)

5. Investment in exploration

Due to significant capital investments, technical risks related to the availability of technology and workforce skills, the quantity of proven oil reserves, climate policies for low-carbon economic development, and political risks, upstream oil activities are subject to economic and financial risks. As developing nations are frequently seen as unfavorable investment destinations, there aren't many international oil companies (IOCs) operating there.

Geopolitical causes and the COVID-19 pandemic's fall in oil consumption have had a devastating impact on the nations that produce it, resulting in major cuts to their national budgets and societal demands. This unrest has delayed new projects, reduced spending on ongoing operations, and collapsed net cash flows for oil exploration and production (E&P) businesses.

The shift to low-carbon energy and public health concerns that affect the demand and supply of non-renewable, carbon-rich commodities will change the risk assessment of upstream oil projects in the next decades.

To encourage the development of their natural resources and the ultimate investment choices of multinational corporations, building resource-rich countries' (RRCs') macroeconomic frameworks, which are governed by fiscal regimes, will be crucial. (Tafur, Lilford, & F. Aguilera, 2022, p. 56)

All oil corporations have focused their investment on the upstream sector and increased their investment strength in oil and gas exploration and development as a result of the historically high oil prices. As a result, the oil corporations give careful consideration to the analysis and prediction of upstream investment in terms of scale and structure so that they may take the necessary actions to adapt it in response to changing circumstances. (Baosheng & Qing, 2011, p. 120)

Oil prices have a wide range of effects on consumer and corporate behavior. The first effect of high oil prices is a decrease in business investments and discretionary consumer income, which in turn reduces future production in many industries and consumer demand. Second, fluctuating oil prices cause customers to put off buying durable goods, lowering investment and oil exporting nations' reliance on oil earnings.

Third, changes in oil prices alter consumption patterns across time and between areas through causing the development and loss of a range of occupations. Finally, as a result of high oil prices, consumer demand and production move from products using a lot of oil to products requiring less oil (such as sport utility vehicles to compact cars). (Crawford, Markarian, Muslu, & Price, 2022, p. 221)

The volatility of oil prices is closely related to both the internal business risk and the industry average risk for investments in oil and gas. Investors should closely monitor the trends in the price of oil in the future in this regard. The times at which various risk factors occur vary, and the risks associated with those factors may fluctuate with time. The dynamic variation of risk factors can be adequately compensated by a dynamic discount rate. (Li, Liu, Luo, & Wang, 2020, p. 870)

An increasing cycle that lasted more than ten years was followed by a slump in upstream oil investment trends in 2015. With the exception of 2010 and 2002, when investments declined due to a significant decline in oil prices, investments in E&P had climbed sixfold since 1999 and had been growing continuously.

However, it should be emphasized that even at the start of last year, many worldwide corporations were declaring strategic reorientations, favoring budgetary discipline and profitability above growth. It is clear that the decline in oil prices since mid-2014 is the primary cause of this collapse. Therefore, the transition that was already taking place has only been hastened and magnified by the drop in oil prices. It is anticipated that this negative trend will persist in 2016, albeit more slowly. (IFP Energies Nouvelles, 2016, p. 10)

After four years of rapid growth (+60% between 2009 and 2013), investments in exploration and production (E&P) are predicted to decline 21% this year to roughly $540 billion, down more than $140 billion from 2013. In 2014, there was a modest 3% increase following four years of robust growth (+60% between 2009 and 2013).

This tendency has been particularly noticeable for independents, whose budgets decreased by 34% as opposed to 15% for majors and only 11% for national companies (NOC), whose budgets also decreased. Only the Middle East managed to avoid the regional downturn, and there, investments are predicted to increase by 3%, helped by NOCs, which account for about 70% of regional investments.

The most severe losses occurred in North America and Europe, where budgets fell by 35% and 33%, respectively. Africa (-22%) and the CIS countries (-21%) had decreases in investment that were quite close to the world average, but Asia-Oceania (-15%) and particularly Latin America (-8%) experienced lower drops. (IFP Energies Nouvelles, 2016, p. 10)

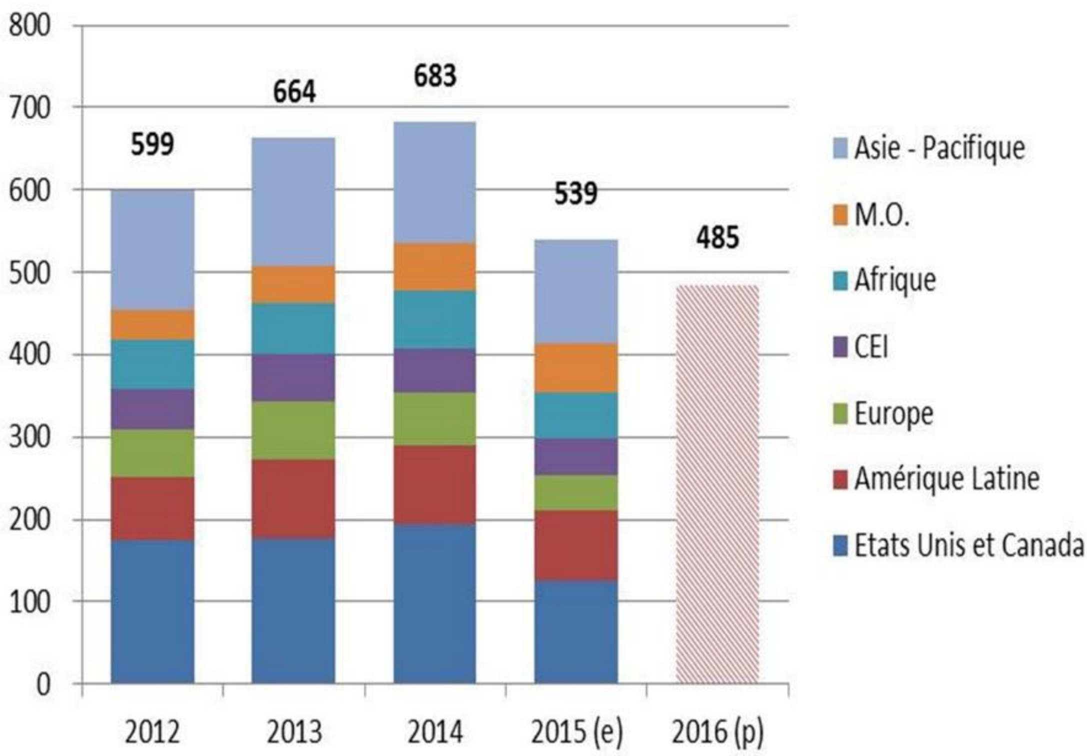

figure 2: Exploration investment (IFP Energies Nouvelles, 2016)

With the exception of the Middle East, every region in the world experienced a net loss in investment, however there were some notable regional variations. Be aware that the relative importance of NOC investments and the severity of their decrease in a particular region appear to be inversely related.

While Latin America and the Middle East, where NOC investments make up between 70% and 80% of the total, were less affected, North America and Europe, where NOCs are less prevalent (apart from Statoil in Europe), had the worst decreases.

Even the Middle East had a modest increase in E&P spending. While the global average in 2015 was 45%, declines in other regions, where NOCs account for 40% to 60% of investment, decreased in the middle of the spectrum. (IFP Energies Nouvelles, 2016, p. 11)

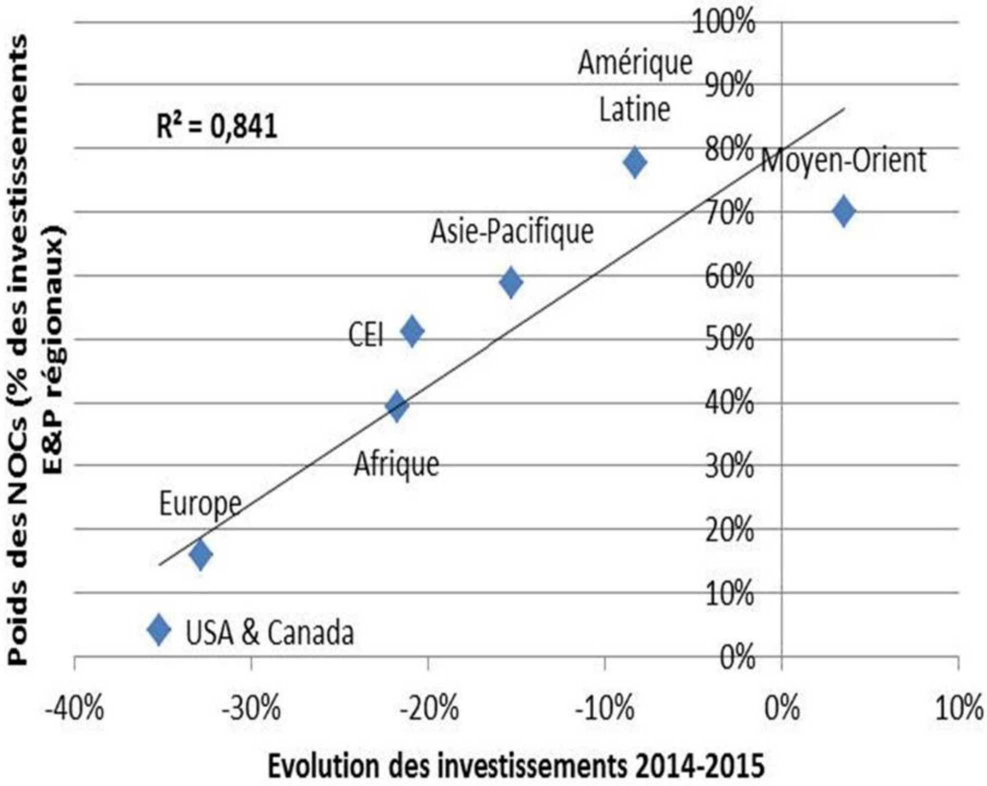

Figure 3: investment evolution (IFP Energies Nouvelles, 2016)

At a time when naphtha-based production benefits from cheaper costs because of falling oil prices, tightness in the petrol market is pushing up ethane prices. Some petrochemical firms are deciding to expand investment in naphtha-based petrochemical production as the region's petrochemical sectors battle with power generation and other industries for gas supplies. The UAE accomplishes this by emphasizing crackers for mixed-feed.

For investments in downstream industries, there is increasing competition among the emirates. Established petrochemicals centers include Abu Dhabi and Dubai, with the former benefiting from lower labor and electricity costs.

At Jebel Ali, however, Dubai is thought to have a better port infrastructure. Where production costs are lower, the other five emirates are also drawing more attention. Alternative locations for investments include the Ras al-Khaimah Free Trade Zone and the Hamriyah Free Zone in Sharjah. Due to its advantages as a port city and a hub for bunkering, Fujairah is also eager to attract more downstream petrochemical investments.

There will be fewer new project announcements as a result of rising feedstock costs, restricted supply of ethane feedstock, rising construction costs, and the expectation of slower demand growth in important markets. The UAE's petrochemicals industry is currently heavily dependent on naphtha as a feedstock, which poses a substantial danger.

Borouge also wants to set up sales and marketing operations in China and India. It has partnered with India's Machino Polymers, which will use PP resin from Borouge to make compounded polypropylene (PP) for the automobile industry.

The majority of the olefins and polymer production capacity in the UAE is located in Abu Dhabi, which also houses the fifth-largest oil reserves in the Middle East. Abu Dhabi has continued to move through with plans to build its petrochemicals industry despite the global economic slump and has made tactical acquisitions in the struggling market.

The International Petroleum Investment Company (IPIC), a holding company that invests in energy and petrochemicals, and Mubadala Development Company, a tool for economic diversification, merged in the first quarter of 2017 in Abu Dhabi. Mubadala Investment Company was the name given to the new organization.

Low oil prices affected both parties. A $130 billion estimate of assets is held by the new fund. According to the government, the new organization would foster growth and synergy across many industries.

The Abu Dhabi National Chemicals Company (Chemaweyaat), a JV with Adnoc (20%), IPIC (40%) and the Abu Dhabi Investment Council (40%) plans to build what Abu Dhabi hopes will be the largest petrochemical complex in the world in the Khalifa Industrial Zone at Taweelah. A variety of downstream polymer and chemical units will be present, along with an aromatics complex and an olefins facility.

According to the company's website, commercial operations would have begun in 2018, however progress on the facilities has stalled in recent years due to low oil prices, which continue to raise concerns about the viability of some high-capex initiatives in the UAE.

It is intended that the aromatics complex will produce paraxylene, mixed xylene, and benzene from heavy and medium naphtha supplied by pipeline from the Takreer Ruwais refinery. The new complex needs a separate export tank farm, a jetty, and loading berths as part of its infrastructure.

The Takreer refinery of Adnoc will be close by in Ruwais, where the Abu Dhabi Chemicals Integration Company (Tacaamol) complex will be constructed at Al-Gharbia. There is no defined deadline for completion, and reports indicate that it will be reduced back.

Borouge also wants to set up sales and marketing operations in China and India. It has partnered with India's Machino Polymers, which will use PP resin from Borouge to make compounded PP for the automobile industry.

While demand for LPG has reached double digits, Africa's need for gasoil and petrol is anticipated to increase by as much as 8% annually. A portion of the rising demand will be met by the expanding domestic energy supplies on the continent.

According to PricewaterhouseCoopers' (PWC) 2016 Africa Oil & Gas Review, Africa produced 8.4 million barrels per day of oil last year, with 77% of that production coming from Nigeria, Algeria, Egypt, and Angola. But East Africa is pushing its way into the spotlight and altering Africa's energy landscape; this action is easily justifiable given the region's abundant oil and gas resources. For instance, Tanzania wants to export LNG by 2025 using its 55 trillion cubic feet of natural gas reserves, and Tullow and Canada's Africa Oil have found 600 million barrels of oil deposits in Kenya's South Lokichar basin.

Although many projects are still in the exploratory phase, investor interest has improved East Africa's standing in the international energy market.

Several East African nations, including Tanzania, Kenya, and Uganda, are overcoming shaky legislative frameworks by adopting bidding rounds, a more open method of resource distribution. Additionally, during the next few years, the East African Community (EAC) plans to invest about $1.5 billion to construct 1,454 kilometers of domestic and intra-regional pipelines. The 784-kilometer pipeline via Kenya, Uganda, and Rwanda will be the longest and will greatly increase gasoline trade between the three nations.

To meet the demands of its thriving middle class, East Africa must act rapidly. According to research by Standard Bank, the number of such homes in eleven sub-Saharan African nations, including Tanzania, Kenya, and Uganda, is predicted to more than quadruple from 15 million to over 40 million by 2030.

As a result, there is a huge demand for oil products, with much of it going towards driving private vehicles on freshly paved roads. To sustain the constantly expanding populations in Africa's cities, the majority of the LPG demand will be met by cooking, which will also enhance the area's environmental credentials. (Tank storage magazine, 2017)

Strong growth always catches the eye of international investors, no matter where it occurs. Now that additional ports are available in Tanzania, Kenya, and Mozambique, the time is opportune to investigate the continent's resources. Only the most resilient players will succeed in this increasingly cutthroat environment, though.

East Africa's economic strength is being led by Tanzania, Kenya, and Uganda, with the entire eastern area anticipated to increase by 5-8% in 2016-2017, according to the International Monetary Fund. The majority of the EAC's democracies are stable, providing investors with some relief from the political unrest that plagues many energy centers in the Middle East and North Africa (MENA). The EAC also requires robust governance and respect for human rights.

Additionally, the market has entered contango as a result of increased oversupply and decreasing crude prices since June 2014. As a result, there has been an increase in investments in oil storage, and dealers who have access to actual oil and storage can increase their profit margins dramatically.

The likelihood of higher future prices has become especially clear over the past three months as a result of an increase in global crude oil stockpiles caused by an excess in production that has caused many trading ports to reach capacity and force traders to hunt for alternatives. Floating storage is still a controversial backup option due to the high costs of very large petroleum tankers. (Tank storage magazine, 2017)

Building on existing solid bases in the Gulf, Asia, and Europe, the shifting market structure has provided a route for international trading and storage companies to penetrate and expand their footprint in new markets in Africa. Oil merchants may grow more daring and obtain their own storage facilities if the surplus lasts. They might also need to expand their missions to better accommodate future development by adding more mixing capabilities and building more jetties.

Governments and national oil firms are also rushing to the east coast of Africa. With a $50 million investment in petroleum storage facilities in Mozambique or Tanzania, Oman is trying to establish a foothold to increase trade of fuel and crude into the vast landlocked interior of Africa. (Tank storage magazine, 2017)

Given core business factors and the intents of key transaction participants, the global bulk liquids storage and infrastructure industry is located in the center of a very active merger and acquisition market.

Although energy is essential to the economy, investors are mostly motivated by upstream 'mining' activities for coal and oil. These, however, include large exploration and commodity price risks, which financial investors are unwilling to accept.

One of the most appealing sectors for investors is energy transportation infrastructure. These investors want to benefit from the sector's resiliency without taking any chances with the underlying energy commodities, such as coal, oil, and gas.

Oil, the most important energy resource, as well as other bulk liquid goods like chemicals and biofuels are moved through liquid storage facilities. Numerous M&A deals have been the result of the size of the opportunity, changes in the price of oil, and the overlapping interests of the actors involved, and many more will follow.

To understand where the transactions are coming from and what will keep them moving forward, it is essential to understand the dynamics of each interested party.

Upstream oil refiners and integrated oil and gas giants have historically controlled oil storage and gearbox assets. The oil strategies have been bringing assets to market in recent times because to the need to balance sheets, release capital in an environment of falling oil prices, and downward pressure on refining margins. A good example is when BP goes to the markets to sell its stake in the Amsterdam oil terminal.

Vopak, the industry leader for independent oil terminals, holds a 10% market share worldwide. Only three other companies—Oil tanking, NuStar, and Magellan Midstream—have anything close to a worldwide scope. Transaction possibilities will continue to arise as a result of the necessity for industry consolidation and the requirement to adapt to shifting global trade patterns.

Vopak, which has been a prominent seller of terminals in the market, and LBC Terminals, which is currently in the market to sell some of their European assets, are the main forces behind this trend.

Nearly all of the major oil traders, including Glencore, Gunvor, Trafigura, Vitol, Mercuria, and Noble, as well as certain regional or smaller oil traders, like Bright Oil, BB Energy, Concord, Galana, and Hin Leong, have invested in and are operating storage terminals as part of their oil logistics infrastructure. Ownership of logistics assets did offer improved supply chain management and the ability to exploit margins that would otherwise be lost in trade.

Recent falls in commodity prices have put tremendous strain on traders' balance sheets, which has restricted their capacity to raise cash over a certain point without capital outflows from current assets. These elements can prompt traders to sell some of their logistics assets in the market, particularly if they can do so through sale and leaseback contracts that allow for operational control to be maintained after the sale. The market debut of Glencore is one example, and others will come.

Oil storage and port terminal assets present an alluring business model with preferred infrastructure attributes for infrastructure funds.

The majority of the money that storage companies make comes from storage fees from renting out tank space. These agreements differ in length and complexity, frequently based on the customer. Many contracts are "take-or-pay," which means that even if the client doesn't utilize a tank, they still have to pay. This guarantees a certain amount of money.

For transferring goods from tanks to transport locations, such as barges, transmission pipes, rail networks, or roads, terminal enterprises demand a fee. These "throughput" fees, together with other services like product heating, mixing, and blending, give investors access to additional revenue streams.

Additionally, as a result of oil storage, these businesses have expanded into bigger liquid industries that now include chemicals, vegetable oils, and even food additives. By lowering the company's dependency on oil-based products like crude, jet fuel, diesel or kerosene, this "de-risks" the firm.

Anyone with the ability to store oil has recently enjoyed rich dividends due to the glut of crude and the contango in the forward curve. The urgent rush to invest in new oil storage assets or buy existing ones has been sparked by these market dynamics.

Over the coming years, investors in infrastructure will continue to pay attention to the oil storage industry. Infrastructure investors indirectly take a stance on the market for the goods they store by investing in these assets, even though they do not directly expose themselves to the commodities market.

But these assets have demonstrated that they can provide mid-teen IRRs for investors willing to take the risk thanks to established clients, advantageous locations, and long-term contracts in place. Investors are interested in creating a network of these assets in addition to standalone economics.

The ability to invest larger amounts of capital in high-return investments will result from this. With an 18x enterprise value EBITDA on the Universal Terminals purchase, Macquarie appears particularly enthusiastic about this investment and is not averse to paying high premiums.

In a different ongoing process, the sale of the assets in Portugal, Spain, and France, Macquarie once more appears to be in the lead. The LBC transaction's positive conclusion may inspire numerous other mediocre independent storage providers to follow suit. (Saikia, 2016)

Recent years have seen a decline in shale gas drilling due to the cheap energy price. Oil prices were between $48 and $75 a barrel in 2021, a significant decrease from the all-time high of $145 a barrel in 2008. Additionally, the long-term trend of decarbonizing energy is gradually becoming popular.

The Office of Energy Efficiency & Renewable Energy reports that in 2017, "the solar industry achieved the target of $0.06 per kilowatt-hour for utility-scale photovoltaic (PV) solar power 3 years ahead of schedule, dropping from about $0.28 to $0.06 per kilowatt-hour (kWh)" The cost of wind energy decreased in 2018 to as little as 2 cents per kilowatt hour. The unexpected decline in solar and wind energy costs has increased their competitiveness and led governments to reevaluate their energy strategies, which will hurt shale gas. (Maierean, 2021, p. 6)

6. Conclusion

This paper's major objective is to clarify the key phases involved in finding oil and gas. The first crucial aspect to remember when thinking about exploration technologies is that, in general, private enterprises engage in exploration as an economic activity. The likelihood of discovery is quite slim.

Geophysical, geochemical, and geotechnical techniques are used in contemporary exploration approaches. Exploration of the Earth's surface can help to image or map subsurface formations that are conducive to the buildup of oil and gas. Gravimetric, magnetometric, seismic, radioactive, and stratigraphic surface investigations are collected using geophysical methods. Geochemical techniques are used to analyze the rocks and soil at the surface for chemical composition.

Location (onshore or offshore), well function (exploration, delineation, development), trajectory (vertical, directional, horizontal), borehole size and complexity (two-dimensional, three-dimensional, extended reach), type (original, sidetrack), measured depth, drilling program (sequence, batch, number of wells drilled), formations encountered, rig type (MODU, platform), mark, and other factors all affect drilling cost.

The amount of energy available to force oil from the reservoir rock into the wells determines how successfully an oil field will operate. There are three energy sources, although their usefulness varies greatly.

Exploration activities are the first step in the development of an oil and gas field. The location of a probable hydrocarbon reservoir is identified using geological and geophysical surveys and research. The findings of these studies just offer data regarding the reservoir's possible location, size, depth, and some characteristics like faults and fracturing.

Given that a sizable amount of the world's energy potential comes from offshore oil and gas resources, deepwater petroleum investment has received a lot of attention. Deepwater oil and gas production projects do, however, carry a larger geology and engineering risk than onshore or continental shelf projects because of the maritime geographical context.

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