CHAPTER 1

Economics of Oil and Gas Production

Nadine Bret-Rouzaut

1 Introduction

Oil and Gas Exploration & Production involves exploring a sedimentary basin to discover a field, developing it to produce the oil or gas that can be extracted from it, and finally reclaiming the site at the end of production.

It is a very capital-intensive industry (the currency unit is one million US dollars, and the budget of many projects is over one billion), entailing multiple and varied risks but, in return, also the potential for high profitability.

Several actors, each with a well-defined role, are involved in enabling the quantities of hydrocarbons needed for consumption to be available on the market. The three main ones are:

- The State
- The oil companies
- The contractors.

To these main actors, one must add banks and insurance companies—to make financing possible—and professional organizations—to discuss and analyze challenges and find the best approaches to confront them.

In addition to these, the local population has gradually asserted itself and acquired influence, although even today in a number of countries the means at its disposal remain limited.

N. Bret-Rouzaut (✉)
IFP School, Paris, France

SciencesPo—Paris School of International Affairs, Paris, France

M. Hafner, G. Luciani (eds.), *The Palgrave Handbook of International Energy Economics*, https://doi.org/10.1007/978-3-030-86884-0_1

2 The Main Actors

2.1 The State

As a general rule (with the sole exception of privately owned land in the United States), the State is the owner of all underground natural resources, including hydrocarbons. It controls oil activities and acts as guarantor of the general interest, in particular when it authorizes companies to explore for and produce hydrocarbons or when it decides to introduce into the law an obligation of local content (through employment of local professionals, manufacturing of equipment in the country, or creation of local companies linked to the oil and gas sector).

Depending on the legal regime applicable to ownership of underground natural resources, there are two possible forms of intervention:

- direct: the holder of mining rights directly explores and produces hydrocarbon deposits either as owner of the land (for privately owned land of the United States) or as the State, through national companies, with or without a legal monopoly (such as it exists, e.g., in Saudi Arabia)
- indirect: in this case, the holder of the mining rights, as the State and by virtue of its power, designates who will carry out the exploration and exploitation of hydrocarbon fields within the framework of the legislation in force and the applicable patrimonial agreement and contractual regime (which can be either a concession, a production sharing contract or occasionally a service contract, as explained later).

In petroleum matters, the State is primarily represented by the Ministry in charge of hydrocarbons (Ministry of Petroleum, Ministry of Energy, Ministry of Mines and Subsoil, etc. depending on the country). But other ministries are also involved: the Ministry of Finance and Ministries in charge of security and environment, labor, and fisheries, if it is an offshore field. In some countries, specialized national agencies will support the Ministry in charge of oil affairs. For example, in Norway the Norwegian Petroleum Directorate provides high-level technical expertise to the Ministry.

2.2 The Oil Companies

We may distinguish several different categories of oil companies. A first distinction is usually made between integrated and non-integrated companies, also called independents. An integrated company has assets along the entire value chain from hydrocarbon exploration to the sale of petroleum products to the final consumer. Vertical integration is expected to enable the company to create more value, by adding downstream profits (from refining and distribution/marketing) to profits from the upstream (exploration and production). Vertical integration can also provide a balance when one of the segments of the value chain faces difficult market conditions, because chances are that in this case the other segments experience favorable conditions. For example, when the price of crude oil is high, upstream profits increase while the downstream activities, for which the price of crude oil is a cost, may be challenged.

In contrast, an independent company is only present in a single segment of the chain, that is, with respect to the discussion in this chapter, only in the upstream: its role ends when it sells the hydrocarbons it produces to buyers that are not linked to it. Independents are much smaller than integrated companies, and frequently quite risk-prone explorers.

Secondly, we may distinguish between national companies (NOCs), in which the State is the majority or sole shareholder, and international companies (IOCs) such as ExxonMobil, Shell, BP, Total, and others, which have their equity traded on stock exchanges and own assets in multiple countries.

These diverse companies must in the end work together. Indeed, it is very rare for a single company to be active in an oil field in the absence of any partner. Exploration risks are extremely high, and the probability of finding a commercial field low. The oil companies will therefore join forces in a Joint Venture (JV). Each individual company normally prefers to take a stake of variable importance in several licenses, rather than concentrate its investment on a few prospects, so as not to put "all its eggs in the same basket". Partners in the same project then sign an association agreement regulating their cooperation, called the Joint Operating Agreement (JOA). This agreement is signed by all the oil companies that come together to ensure the proper execution of the contract. The national company may be one of the partners of this JV when the State wishes to participate directly in operations, assuming the same rights and obligations as other companies, up to its share of participation.

The JOA defines the co-responsibility of the partners, the legal and fiscal transparency of each partner, the financing rules (procedure for calls for funds, invoicing methods, co-financing of expenses), and the sharing of results, as well as the rules for decision-making through a management committee. Operations are initiated, prepared, and directed by the company entrusted with the role of operator, whose responsibilities must be clearly spelled out in the JOA. The operator is also the representative, who communicates on behalf of the Association and represents it in all relations with the State. In the event of disagreement during the commitment period, it is usually the operator who decides. But sometimes some of the partners may decide to work on "sole risk", that is, to assume full responsibility for the work that the other partners do not want to do.

2.3 The Contractors

In the past, oil companies designed, planned, and carried out the engineering for oilfield exploration and development. This involved the possession of seismic and drilling equipment and the employment of the teams necessary for their operation. Then, in the 1980s, oil companies progressively decided to refocus on what they considered to be their core business, outsourcing activities not considered to be part of the core to oil service companies. The pendulum has repeatedly swung between internalization and outsourcing, but overall the trend has been to outsource more and more activities. The oil and gas contracting sector now carries out much of the work subcontracted by oil companies: geophysical activities (acquisition, processing, and interpretation of seismic data); drilling and related services; as well as engineering activities, such as underwater works (pipe laying) or platform construction (shipbuilding). In addition, there is a multitude of service providers including tool manufacturers (geophysics and drilling), metal construction, mechanical engineering, and engineering companies. The common point for all these companies is that they are service companies for the oil industry, first, second, or third tier providers.

In the past, the oil and gas contracting industry frequently developed in parallel with the exploitation of local hydrocarbon resources (the United States, the United Kingdom, Norway, etc.). In recent years, Chinese companies have entered this sector and have rapidly gained significant market shares. However, the United States is still the reference country for oil activity, which has led to the creation of a powerful oil-related industry, giving some companies a leading position today: examples are Schlumberger, a company that was originally French, or Halliburton. But exploration, development, and production operations involve multiple highly specialized competencies (driller, mud specialist, helicopter company, diver, etc.) so that oil companies must sign many contracts (one contract with each service company), which is a long and management-intensive process. To overcome these disadvantages, oil companies are increasingly opting to deal with only one company and sign integrated service contracts.

Faced with this demand, contractors embarked on a major industrial restructuring process in the early 1990s, mainly through external growth. Many mergers and acquisitions have thus taken place, and the industry has consolidated.

3 The Different Phases of Exploration-Production

3.1 Exploration

The purpose of exploration is to discover an oil and/or gas field. It involves three areas of expertise: geology, geophysics, and drilling.

3.1.1 Geology

The first step in the process is when geologists study the geology of large areas to define specific areas that may contain hydrocarbon accumulations. Then, geologists carry out geographical surface studies to verify the presence of the triplet essential for any conventional deposit:

– a source rock that generated hydrocarbons millions of years ago

- a reservoir rock which, due to its porosity characteristics, may have accumulated hydrocarbons in its pores
- an impermeable overburden rock that retained the hydrocarbon molecules trapped inside the reservoir rock.

Then they will study the topography and visible structures in order to deduce some characteristics of the formations and structures of the subsoil. When the region is mature (proven existence of hydrocarbons), they use many existing sources of information from databases of companies, public agencies, and so on. Geologists then synthesize all the information acquired in the form of subsurface maps at different scales. But knowledge of the characteristics of the surface terrain is not sufficient to extrapolate the properties of the subsoil. In addition, in submerged areas, nothing is visible. This is why geophysical exploration methods are used.

It is difficult to estimate the cost of geology, because geologists are present throughout the upstream chain and the related expenses are treated in association with other expenses.

3.1.2 Geophysics

Geophysics consists of making measurements of physical quantities of the subsoil and interpreting the results in geological terms. These geophysical methods are based on three approaches, two of which are marginal: magnetometry and gravimetry. The main approach is seismic reflection, which makes it possible to carry out a proper echography of the subsoil.

Seismic reflection consists in sending elastic waves into the subsoil, which propagate through the rock masses, then refract and reflect on certain geological discontinuities called mirrors. Like echoes, reflected waves then rise to the surface where they are recorded by sensors (geophones on land, hydrophones contained in a streamer at sea) that convert ground vibrations into electrical voltages transmitted to a recording laboratory. The seismic recordings collected by the geophysicist are then processed by powerful computers to increase the signal-to-noise ratio.

Seismic results provide a good idea of the underground structural formation—layer inclination, continuity, folding—that can make visible possible traps constituting potential target locations for drilling.

3.1.3 Seismic Cost

The cost of a seismic campaign can be broken down into:

- Cost for field data acquisition
- Cost for data processing (computer processing)
- Cost of interpretation (analysis and understanding of results to enable decision-making).

The acquisition of seismic data at sea is easier than on land, due to the ship's ease of movement in all directions. This allows covering a large area at lower cost.

As with acquisition, routine seismic processing is outsourced to service companies. Processing costs are usually significantly lower than acquisition costs. Once the seismic data has been acquired and processed, it must be transformed into information that can be used by decision-makers. The processing of data must be done under the control of specialists. This translates into personnel and IT costs that can range between a few hundred thousand and one million dollars per seismic campaign.

The total cost of a seismic campaign thus amounts to between a few million dollars and a few tens of millions of dollars, depending on the difficulty of access, the type of coverage desired, and the area covered (we can calculate a cost in $/km^2). These costs are also related to the severe competition between service companies in local markets, with the award of seismic surveys being subject to competitive bidding in the countries concerned.

Thanks to geological and seismic data, it is possible to judge the prospect's interest and eventually make the decision to drill an exploration well, because only direct access to the subsoil, through drilling, can provide certainty that a field exists.

3.1.4 Drilling

The objective of drilling is to reach the target by perforating the geological layers over several thousand meters. A hydrocarbon field may be several kilometers from the surface, but never more than eight kilometers. If the hydrocarbon molecules have ventured into greater depths, they have been completely destroyed by the pressure and temperature at these depths. The most common drilling technique is to attack the rock with a rotating drilling tool, the drill bit. The driller must at all times ensure that there is a balance between the pressure inside the well and the pressure in the geological layers traversed. Drilling progresses at a rate of a few meters per hour, more and more slowly with increasing depth, punctuated by difficulties and regular replacement of the drill bit, which requires the entire drill string to be raised.

The main difference between onshore and offshore drilling is the support on which the rig must be installed at sea: platforms resting on the seabed (jack-up platforms used in shallow water), semi-submersible or floating structures (rather reserved for drilling in deeper waters). These devices are moved after each prospect drilled.

Whether the drilling leads to a discovery or not, it provides the geologist with important information in the form of cores, cuttings, and electrical records at the bottom of the well.

3.1.5 Cost of Drilling

Drilling of an exploration well generally lasts two to six months, depending mainly on the depth and hardness of the layers traversed, and 70 to 75% of the cost will be directly proportional to this duration. On the other hand, on average only one in five wells, or even only one in seven in poorly known areas, leads to the discovery of an economically exploitable reservoir, which means that the oil company must take into account the costs of all wells even if they have not led to a discovery.

The cost of drilling is higher than the cost of geology-geophysics and represents the bulk of the costs of an exploration program. The rental of the drilling rig from the contractor alone represents 20 to 40% of the total cost of drilling. The daily cost of renting a rig varies with its power, which depends on the depth of the well and, at sea, the depth of water in which the rig will be positioned. It also varies according to the rig utilization rate, that is, the ratio between the demand of oil companies and the supply of available drilling equipment, which varies with the price per barrel of crude oil.

To this cost must be added the costs of supervising the work, the cost of consumables (tubes, etc.), and the cost of other equipment and expertise required for drilling (logistics, mud, logging, etc.). In the end, a well will generally cost between a few million and a few tens of millions of dollars. An offshore well will often cost between 3 and 5 times more than an onshore well, even with a similar duration. Wells in extreme areas and/or at very great depths can cost several hundred million dollars.

3.1.6 Total Cost of Exploration

Exploration costs include seismic, geological, and geophysical interpretation and exploration drilling, including well testing.

Exploration expenses are, by definition, incurred before discovery and therefore have a direct impact on the company's accounts with two fundamental consequences:

- they will only be "refunded" if there is a commercial discovery; however, the probability of success of an exploration program is only 10 to 30%.
- they can only be financed from equity; given the high risk of failure, no bank will lend money to an oil company for exploration.

Exploration expenditures can vary over a very wide range. They may be limited to the cost of a seismic campaign and a dry well in the case of unsuccessful exploration. In this case, the oil company records a financial loss, even if this exploration campaign allowed the acquisition of additional information on the studied area. We express the cost in $/boe (barrel oil equivalent) by dividing the total amount of expenditures by the discovered reserves in barrels: depending on the region and time, this figure will generally range from $2 to $5 per boe.

3.2 Development

When exploration leads to a discovery, the next step is delineation (of the reservoir boundaries) and reservoir appraisal (e.g., homogeneous reservoir rock characteristics across the deposit). This provides additional information to confirm the discovery and assess with better accuracy the amount of reserves (quantity of hydrocarbons that can be extracted) and production conditions. Economic studies (crude oil/gas price, taxation, etc.) complement the technical studies to answer the essential questions: Is the field commercial? Should it be developed? If so, according to what scheme? Does it fit well into the company's strategy and its financial resources?

Once the decision to bring the field into production has been taken, the field must be developed, that is, all the equipment needed to exploit the field must be put in place: transport networks, production facilities, treatment and metering equipment, drilling of new wells, and so on.

3.2.1 Production Drilling

Unlike exploration drilling, production well drilling is a repetitive operation whose duration is easier to plan, and its costs are often better controlled. On average, production wells are drilled faster than exploration wells (learning curve).

In addition to drilling times, it is necessary to consider the completion times needed to connect the producing area to the borehole. The completion must ensure that the walls of the wellbore are secure. Today, while the vast majority of exploration or delineation wells remain vertical, production wells often use diverted or horizontal drilling techniques, particularly when the drilling area is inaccessible or urbanized or offshore, to limit the number of platforms or to exploit a deposit of low thickness or permeability (the latter being the case of shale oil and shale gas deposits). Multi-drain drilling can also be used when you want to produce several parts of the same reservoir simultaneously.

3.2.2 Production Drilling Cost

The cost of a production well is not very different from that of an exploration well. On the one hand, there is an additional cost due to the fact that the well must be equipped to be able to produce efficiently, but, on the other hand, thanks to experience, the well is drilled more quickly. In the case of a horizontal well, the cost is 20 to 30% higher than that of a vertical well, but in return, well productivity is increased by sometimes a factor of 3. Environmental constraints also can have an impact on well costs. These may be increased by the need to treat drilling waste, such as rock cuttings or various fluids, in order to comply with the country's environmental regulations.

3.2.3 Floating Supports

At sea, the equipment must be installed on floating supports. At shallow water depths, we can use a fixed structure (jacket), but for depths beyond a few hundred meters of water (currently, we are able to produce more than 3000 m of water, to which several thousand meters are added in the subsoil to reach the field), we then use one of three alternatives:

- A semi-submersible platform, anchored to the sea floor to be kept in place, and with a large and deep hull so as to have a low center of gravity and good stability
- A SPAR, a structure consisting of either a solid cylinder or a cylindrical part and a metal mesh with catenary anchor lines
- A Floating Production Storage and Offloading (FPSO): they were initially modified tankers used only for storage and loading of crude oil (FSO). Then, as the available tankers became scarce, new boats were built. By allowing autonomous production, the FPSO are more and more used in deep offshore areas where there are no export networks such as Brazil and West Africa.

Depending on the structure chosen, it will have to be built (or bought, or rented, if it is an existing structure) and installed during this development phase.

3.2.4 Total Development Costs

Development investments include the costs of development drilling (production wells and, where applicable, injection wells) and the costs of production facilities with separation and processing units, storage tanks, pumping and metering units, and discharge systems (pipelines and loading terminals).

Except for marginal cases such as small satellite fields whose development is very rapid, the development phase generally lasts 2 to 4 years.

In the development of an oil field, investments can reach several billion dollars. Identifying and evaluating the key parameters of a development are essential to the proper definition and profitability of the project. Some parameters, such as the situation of the field, the depth of the target, or the ocean-meteorological conditions, have strong influence on costs. Development costs represent between 40% and 60% of the total cost of the project.

Depending on the region, the cost of development varies considerably. In most cases the range will be between 7 and 15 $/boe, but it can be much more for complex fields.

3.3 Production

It is impossible to recover all the hydrocarbons present in a reservoir because of the action of capillary forces. On average, around 80% of the gas and 30 to 40% of the oil originally in place can be recovered. The time profile of production is characterized by a build-up phase, followed by a plateau that can be maintained for a time comprised between a few months and 2–3 years (or longer for large deposits), and finally by a decline phase until the end of the deposit's life.

As production progresses, reservoir pressure drops, reducing the eruptive capacity of hydrocarbons, particularly of oil. Initially, the wells produce spontaneously (i.e. without stimulation), until the production of water becomes excessive. This so-called primary recovery ranges between 25 and 30% of oil in place and in the majority of cases does not allow economically sufficient volumes of oil to be extracted. This is why it is often financially interesting to implement methods of assisted recovery after a certain operating time, such as pressurized water injection (the most widely used) or gas injection. These methods allow higher recovery rates of up to 40 to 60%. To go even further, so-called tertiary recovery processes can be used, such as chemical or thermal methods, to improve spatial scanning and reduce capillary forces. Tertiary methods can provide an additional recovery of 5 to 10% of the oil in place. However, all these methods have a cost, and it will be necessary to verify that their implementation brings an improvement in profitability. This also depends on the characteristics of the company exploiting the field: large companies frequently face higher costs and may divest fields reaching the end of their life to smaller, more nimble companies.

In the particular case of shales (oil or gas), as these formations have low porosity and permeability, hydraulic fracturing will be required to create cracks in the reservoir using high hydraulic pressures and extract significant quantities of hydrocarbons. The introduction of retaining agents such as sand or small marbles keeps these fractures open. But as productivity declines very quickly in these formations, it will be necessary to constantly renew fracturing to maintain an acceptable level of production.

The sum of exploration and development costs constitute total capital expenditure (CAPEX).

3.3.1 Operating/Exploitation Costs

Operating costs (OPEX) are defined as all expenses related to the operation of a production facility. They can be classified as (Fig. 1.1):

- fixed (independent of production level) or variable (proportional to production level)
- direct (production, maintenance of wells, inspection, logistics, safety) or indirect (technical assistance, headquarters staff)
- according to their nature: personnel costs, consumption (fuel, energy, etc.), telecommunication costs, rentals, service, and maintenance contracts.
- according to their object (production, maintenance, security, etc.). This classification allows cost accounting closer to the operator's objectives.

One can find a great diversity of situations, depending on the field: OPEX will generally range widely, between 7 and 15 \$/boe, depending on the difficulty of extraction (gas, oil, heavy oil, etc.), field size, geographical location (land or sea), region (desert, jungle, far north, temperate zones, etc.).

As a general rule, the amount of operating costs in \$/boe is therefore of the same order of magnitude as development costs, but with one major difference: development costs must be financed at a time when there is still no cash inflow,

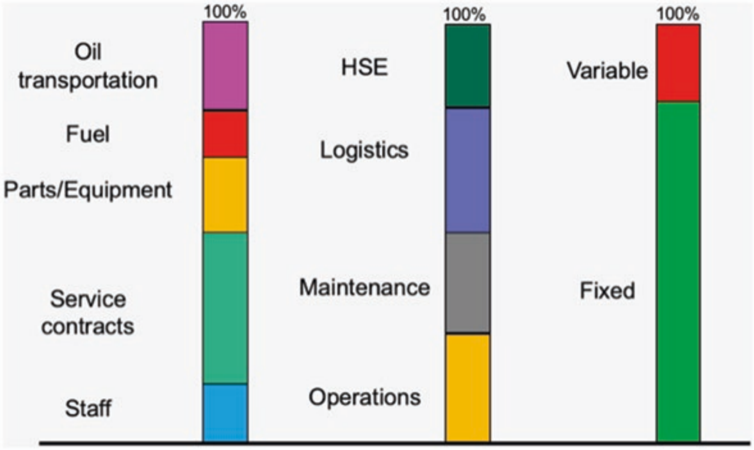

Fig. 1.1 Cost structure according to different types of breakdown by major cost families. (Source: Courtesy of Eric Descourtieux, Trident Energy)

since the field is not yet in production; while operating costs are funded from sales. Nevertheless, controlling operating costs is a daily concern for the operating teams, who must ensure an optimal level of production in complete safety and at the lowest cost.

3.4 Dismantling—Site Restoration

Finally, after a production period often of the order of 15 to 30 years, the limits of economic recovery of hydrocarbons are reached and the production structure is dismantled; if onshore, it is also necessary to rehabilitate the land. These operations can be very penalizing (the cost of dismantling an offshore platform is equal to that of its installation), especially since they occur at a time when the oil company no longer enjoys the cash flow from exploitation. It is therefore necessary to provision and take into account these costs in economic calculations from the start.

3.5 Technical Cost

Technical cost is defined as the total expenditure from exploration to decommissioning, that is, the sum of exploration and development investment, operating and maintenance costs of existing facilities, and decommissioning costs. The respective weights of these different categories of expenditure vary according to the project, but a few orders of magnitude can be given as a percentage of the overall cost of the project:

- 5 to 10% for exploration

- 35 to 45% for development
- 35 to 45% for operating and maintenance
- 5 to 10% for dismantling.

These costs are optimized to achieve the highest profitability. For example, it is sometimes preferable to reduce development investment and let operating costs increase accordingly, by renting the production platform rather than buying it. This will reduce expenses before production begins, and rental expenses will be charged annually during the production phase. Such optimization is aimed at the best possible value creation. In the end, technical costs are highly variable from one project to another, but will generally be in the range of $10 to $35/boe, with offshore projects costing more than onshore. The technological challenge of offshore production and more complex logistics explain this difference.

3.5.1 Cost Reduction

Companies must pursue two simultaneous objectives: increase production without endangering the production level of the reservoir and keeping costs as low as possible.

Two factors play a fundamental role in the evolution of costs:

- Technical and organizational innovation
- The level of economic activity, and more specifically the price of oil.

Regarding the first factor, the oil industry is relatively conservative in its technical choices, preferring to use proven methods to reduce the risks associated with the implementation of any new technology that could lead to a delay in the start of field production. However, some companies are ready to innovate, particularly when innovation allows significant gains or when the technical parameters of development require new solutions to reach new reserves. In terms of R & D, in response to the pattern of increasing outsourcing by oil companies, contractors have come to play a more important, and now even indispensable, role on the international oil scene.

Nowadays, a large part of innovation results from access to massive amounts of data, which makes it possible to have more reliable understanding and better forecasts (e.g., of oil prices) or optimize investment costs by managing the exploitation of a field remotely (the platform's size is reduced to a minimum to accommodate only a few people, the majority of the team remaining on land, with remote connections giving access to all the data necessary for the proper functioning of the exploitation).

But innovation is not limited to the technical sphere. Cost reductions can also result from organizational innovations, particularly in logistics. Rethinking the entire organization of a project to optimize each link, eliminating as much as possible redundancies without harming safety or the environment, using every possibility of connecting to existing installations, and finding associations that allow synergies are themes increasingly at the heart of the drive for optimization.

With respect to the influence of the oil price, costs will evolve according to the market situation (balance of demand and supply) of the sector in question (geophysics, drilling, construction, etc.). For example, the price of platforms will be sensitive to the costs of raw materials (steel in particular), the workload of platform-building companies, and the availability of construction sites. For the same type of platform, price differences of 20 to 30% can be observed, depending on the market situation. A construction site may be willing to accept a low price to just cover its operating costs and avoid closure if demand is low. On the contrary, in a situation of overheating, when the order books are close to full, suppliers and manufacturers have the power to negotiate and sign with the highest bidder. Maintaining, at each stage, effective competition between contractors when awarding work contracts helps reducing the final cost of a project. Consequently, there is a correlation between costs and oil prices: when the price of oil is high, companies have abundant cash from their producing fields and are therefore more willing to invest. Since they all have the same reaction at the same time, markets are quickly tightened. When the price of crude oil is low, we have the opposite reaction.

Cost control is now a priority for all companies, whether contractors or producers; they must set up procedures to ensure rigorous budget monitoring and permanent data exchange between the various entities involved in the project, whether with the client or the company's financial department.

4 The Patrimonial Agreement

The State, as responsible for the general interest, owns the natural resources of the subsoil (with the exception of private land in the United States), gives the authorization to explore for and exploit hydrocarbons, and controls oil activities. In each country, there is a law that provides the legal, financial, and fiscal framework for existing or potential exploration and production activity. It defines, inter alia, the applicable legal regime, the authority of the Minister responsible for Petroleum Affairs, the role of the national company (if there is one), and the tax regime.

Two modes of State intervention are possible:

- The State directly develops hydrocarbon fields through its national company, as in Saudi Arabia
- The State designates a company to carry out exploration and exploitation operations. It decides on the regime to which the chosen company will be subject, within the framework of the legislation in force (the regime can be a concession contract, a production sharing contract, or a service contract).

4.1 Procedures for Awarding Mining Titles/Contract

The granting of mining titles or oil contracts in available exploration areas can be decided through one of two alternatives:

- Negotiation process. In this case, companies are encouraged to submit an offer covering the terms and conditions of the proposed oil agreement. The State may then enter into negotiations with the proposing company, in order to reach a mutually acceptable agreement
- International call for tenders (also called "exploration round"). The State opens blocks and sets the conditions of the call for tenders (terms of submission, availability of data). It provides companies with a standard contract in which certain terms (work commitments, expenses, economic terms, participation rates, etc.) are left to the company to propose. After studying the offers, two cases are possible: either acceptance of the best offer, without negotiation (competitive bidding), or negotiation with the company having submitted the best offer, in order to improve the proposed terms and finalize a contract.

The tax system is defined by the State. There are two main alternative solutions: either a concession or a production sharing contract. The State can also offer only service contracts, but oil companies are reluctant to accept this solution, yet are sometimes forced to accept it if they want to work in the country.

5 Concession

In the concession regime, the legislation and regulations define the applicable framework in a detailed and non-discriminatory manner. A concession regime is the rule in Europe, the United States, Canada, Australia and Latin America, with few exceptions.

The concessionaire becomes the holder of an exploration license from the State, followed by an operating license (often called concession) in the event of a commercial discovery of hydrocarbons. The concessionaire exercises the exclusive right to explore for and exploit hydrocarbon fields over a defined area and for a limited period of time.

The concession contract is a document of about a hundred pages, whose various clauses can be grouped into three main categories:

- technical, operational and administrative clauses, covering the practical aspects of the conduct of operations during the various phases
- economic, fiscal, financial and commercial clauses, covering rent sharing between the parties, accounting for oil costs, valuation of production.

Subject to the fulfillment of all contractual obligations, the concession holder may withdraw at any time during the exploration phase or upon its expiry, if no commercial discovery has been made.

Under a concession contract, the oil company:

- owns the facilities until its mining rights expire
- exercises the exclusive right of exploration (in the form of an exploration permit or license).
- obtains a concession or operating permit (lease) to develop a commercial discovery.
- owns and freely disposes of all production at the wellhead, subject to certain obligations such as royalties and sales on the local market
- exercises this right for a limited period of time, at the end of which the exploited fields revert to the State.

Under the concession regime, government revenues are obtained through taxation and are therefore voted by Parliament, meaning that Parliament can decide to change the "rules of the game" at any time.

Government revenues fall into the following main categories:

- bonus: some concession agreements provide for the payment by the holder of an amount payable on the date of signature of the contract, called "exploration bonus". This can range from several million to hundreds of millions of dollars and constitutes a significant financial effort for the holder, especially since this bonus is paid before any discovery, and lost if there is no discovery. For the country, it represents a very attractive, immediate income source. In other cases, the bonus may be paid at the start of development or production. For the same country, there may be several bonuses paid at different times during the project.
- surface fees: the holder may be required to pay annually to the State a rent proportional to the area of his exploration/production permit. The amount of these rents is generally quite low (usually a few $/km^2$ per year)
- royalty on production, equal to a percentage of the value of the production paid to the State by the holder, either in cash or in kind. It can be considered as a tax directly proportional to the value of production, in the same way as a tax on turnover, regardless of profits. The calculation of the royalty depends first of all on the applicable rate. Royalty rates are generally different for crude oil and natural gas, and lower for the latter. In order to modulate the royalty according to the characteristics of the fields in exploitation, the contracts may provide for progressive rates according to production volumes.
- the holder's income tax. The holder is subject to a direct tax on the income resulting from his production activities, but also from the transport, refining or liquefaction of natural gas.
- possibly an additional tax on oil profits. The payment of a royalty on production and a direct tax on profits may be considered by the State to be insufficient in times of high crude oil prices. In this case, the State introduces a specific tax on the profits from hydrocarbon production.

6 Production Sharing Contracts

Under the production sharing regime, the relationship between the State and companies is governed by a contract signed after multiple negotiations. Therefore, each contract will to some extent be different.

In this regime, the contractor does not hold a mining title, as the contract with the State does not create such a title. It is often a national oil company that holds the mining title, and the contract is then concluded with this national company, as the representative of the State, in the form of a joint venture. The State's direct participation in the joint venture may be an option.

The oil company that signs the production sharing contract with the State is called a contractor. The company:

- is a simple service provider;
- bears the technical and financial risks of exploration;
- has the exclusive right to develop and exploit the field if there is a commercial discovery;
- does not own the facilities it has paid for, but has the exclusive right to use them free of charge for the duration of the contract. The transfer of ownership can take place either at the time of installation of the facilities, or after full recovery of petroleum costs;
- receives a remuneration limited to a certain fraction of the production and consisting of two parts:
- cost oil, which corresponds to reimbursements of expenses (CAPEX and OPEX) financed by the oil company, but with an annual limit, the "cost stop", equal to a percentage of the production valued. The balance of oil costs not yet recovered in one year is then recoverable in subsequent years. However, any reimbursement should only be made after the control of the ministry in charge, which may reject expenses that it considers illegitimate;
- and a share of the profit oil, the "Contractor profit oil". The other fraction paid to the state is called "State profit oil". Indeed, after deduction of the cost oil, the remaining part, called profit oil, is shared between the State and the oil company according to a percentage indicated in the contract;

It is increasingly common to also see the payment of a royalty envisaged in a PSC, in the form of a percentage of the production valued and deducted immediately from production. Sometimes, a PSC may even include a tax that will be deducted from the Contractor profit oil.

7 Comparison Between Concession and PSC

The Concession and the Production Sharing Contract regimes each have their advantages and disadvantages. Of course, oil companies cannot choose between one and the other: they have an obligation to accept the system in force in the country at the time they undertake exploration. In a nutshell, it can be said that the main advantages of the concession are:

- the oil company owns a mining title and the oil installations, and it becomes the owner of all production at the wellhead (less any quantities corresponding to the royalty, if it is paid in kind)
- it is generally possible to consolidate different mining titles in the same country, and positive with negative pre-tax results, thus minimizing the final tax payable.

The production sharing contract does not have these advantages, but on the other hand:

- it results from a negotiation between the company and the State, which gives the former more latitude to be flexible on points that are less important to it and, on the contrary, rigorous on what is non-negotiable from its point of view
- in most cases, the accounts are prepared in dollars, providing a more accurate view of the results, especially when the activity is located in a country with high inflation.

8 Service Contract

Service contracts are concluded by the national company of the producing country and enlist oil companies as contractors, with the task of carrying out exploration, development, and/or exploitation work on their behalf. Service contracts are mainly used in the Middle East and Latin America, but their spread remains limited because they are of little interest to oil companies, which get only a financial reward (no entitlement to oil or gas), with no possibility of substantial value creation.

Two categories of service contracts exist, depending on the level of risk taken by the oil company:

- risk service contracts (known as agency contracts), under which the contractor is only reimbursed for his financing in the event of production, and risks losing whatever sum investment if no production occurs;
- technical assistance or cooperation contracts, without risk, to carry out specific work in return for adequate remuneration.

9 Economic Studies

Throughout the project, economists will be required to carry out economic studies.

When you are in the prospecting phase, the purpose of the study is to evaluate the commercial interest of an exploration objective. The task begins with a geological study that defines the potential accumulation of hydrocarbons and the probability of success of an exploration well. Based on three geological scenarios, described as “mini”, “mode”, and “maxi”, the team in charge will define, often by analogy with similar fields, the potential development architecture and the investment and operating costs associated. According to these data, an estimate of potential profitability is reached, to help decide whether to implement the proposed exploration program. The relevance of the analogies and extrapolations made in this type of approach will depend on the reliability of the available databases. Therefore, this method of analogy reasoning has limited validity when the assessment must include the use of new technologies. When there is a discovery, the sanctioning of a project will be based on a detailed economic study that integrates four types of data:

- the production profiles, established by the reservoir engineers based on the characteristics of the reservoir and the amount of reserves
- investment and operating costs, assessed by the experts in the estimation
- the valorization of hydrocarbons. Since it is impossible to predict the price of oil and gas over a horizon of several years, scenarios are used. In the past, the focus was on developing complex scenarios with different variations of price each year. Presently, companies rely on fixed price scenarios in constant or current currency and select two or three alternatives, between an optimistic vision (high crude oil price) and a pessimistic one (low crude oil price)
- the contractual and tax conditions that exist in the country in question.

Economic studies focus on studying the profitability of the project by calculating mainly the Net Present Value (NPV) and the Internal Rate of Return (IRR) of the project. The NPV is the sum of the annual and discounted net cash flows. If it is positive, the project is profitable since in this case, the cash flow generated reimburses investment and operating costs plus taxes, taking into account the cost of the capital invested and adding an extra value. The internal rate of return of a project is the value of the discount rate that cancels its NPV. If the project’s IRR is higher than the applicable discount rate, the NPV is positive and therefore the project is profitable. The threshold discount rate chosen by the company is therefore a determining factor. In theory, this rate results from an estimate of the cost of capital used by the company, but in reality, it will depend on the management strategy: choosing a relatively high value leads to selecting only fewer very profitable projects and rejecting opportunities that could then be chosen by the competition. Choosing the lowest value compatible with the cost of capital will allow more numerous projects, but at the expense of profitability.

It is clear that the final decision will be based on many other elements, such as the company's overall strategy or the local strategy in the country in question: for example, if the company is negotiating to obtain new permits, it will be good practice to reach an agreement for fields already discovered. The search for an optimal portfolio requires a diversified portfolio that spreads risks: deep offshore in areas where the geological potential is high, projects in countries with high political risk but high profitability, projects with low profitability but in "safe" countries corresponding to a risk-free investment, and so on. This diversification will be all the more possible as oil companies are used to working in partnerships: multiplying the number of projects reduces the overall risk of the portfolio. However, the risk associated with a fall in the price of crude oil must never be forgotten, because the sensitivity to this parameter is very high, even if in some countries tax mechanisms can serve as shock absorbers (e.g., the royalty rate can be correlated with the price of crude oil).

Upstream Petroleum is a sector that faces many challenges. There are more than enough resources to meet the demand for hydrocarbons in the coming decades. But these resources will have to be developed at lower cost, especially when the price of crude oil is relatively low, which requires the discovery of new technologies, the implementation at all levels of the digital transformation, and the access to more efficient processes. Therefore, investment in R & D must be commensurate with the stakes involved.

Beyond these operational challenges, the main challenge is now the obligation for these companies to decarbonize in order to respond to the imperative need to reduce CO_2 emissions, as hydrocarbons represent a significant portion of these emissions. Depending on the distribution of their assets across the globe, their percentage of oil production versus gas production, the latter being less CO_2 emitting, and local environmental policies, the response will not be the same for all companies; for example, they can put in place procedures to reduce methane leaks (e.g., in maintenance), inject CO_2 into the subsoil, use electricity from renewable energies, and so on. Finally, most companies in this sector have started to diversify by developing their asset portfolio through equity investments or acquisitions of companies in the renewable energy sector. And for all of them, financial pressure is on the agenda of their top management: How to maintain profitability at a good level with an increasingly volatile crude oil price and equally volatile costs? Which niches should be invested in? How to retain the loyalty of current shareholders, some of whom wish to turn away from fossil fuels? How to attract new investors for risky projects in an uncertain environment? and so on.

This industry is undergoing a real transformation, and it will succeed only if the men and women who make it up show intelligence, curiosity, and responsibility.

Bibliography

Bret-Rouzaut, Nadine & Favennec, Jean-Pierre, Oil and Gas Exploration & Production, Reserves, Costs, Contracts, Editions Technip, 2011.

Darmois, Gilles, Sharing the oil rent, current situation and good practice, Editions Technip, 2014.

Inkpen, Andrew, Michael, Moffett, The Global Oil & Gas Industry, PennWell, 2011.

Johnston D & Johnston D, International Petroleum Fiscal System Analysis—State of Play, OGEL (Oil, Gas & Energy Law Intelligence), 2011.

Kasriel, Ken, Upstream Petroleum Fiscal and Valuation Modeling in Excel: A Worked Examples Approach, The Wiley Finance Series, 2013.

National Energy Technology Laboratory (NETL), US Department of Energy, Carbon Dioxide Enhanced Oil Recovery, March 2010.