7

Offshore Oil and Gas

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Executive Summary

Driven by low selling prices, high production costs and the development of new onshore exploitation techniques, offshore oil and gas activities are experiencing a significant decline. The European sector is mainly composed of private companies that operate mostly at the global scale. However, the production from its territorial waters accounts for 9% and 13% respectively of the total oil and gas consumption in Europe, respectively. Thus, this decline can undermine the energy interests of the EU and especially, the economic activity of the North Sea countries (responsible for the production of virtually all of the oil and more than 80% of the gas).

Despite this negative outlook, the development of new and more efficient subsea exploitation systems can provide an important boost to the sector. However, in a Blue Growth context, the main importance of this industry relies on its important legacy of infrastructure, knowledge and experience (skills, business models, concepts of permanent occupation of the marine environment, etc.).

With this in mind, this chapter describes the main features of the offshore oil and gas industry along with the opportunities and barriers that it presents for the development of Blue Growth and MUS/MUP concepts.

7.1 Introduction

By value, technology and geopolitical status, the offshore oil and gas sector (O&G) is by far and away the most important sector in the contemporary Blue Economy. Offshore O&G came to prominence in the 1970s and currently

accounts for about 37% and 28% of the total O&G global production respectively (WOR, 2014). Companies continue to extend their areas of operations, with "Exploration and Production" (E&P) in ever more extreme and hostile areas. E&P is set to take off in the Arctic Ocean as the ice retreats; fields are already in production at the so called 'Atlantic Frontier' between Scotland and Faroe. The 1970s extreme of North Sea working at depths of up to 300m is replaced by a contemporary technology of working at depths in excess of 1500m. In contrast to the transient activities of fisheries and shipping, the offshore O&G sector introduced the concept of semi-permanent occupation of maritime space. It introduced the idea of fixed platforms at sea which could be supplied with materials and services for the production of O&G and a safe home for thousands of workers, hundreds of kilometres from land. The sector has led the way in maritime health and safety and in the development of risk assessed regulation to control operations and protect the environment.

However, the offshore O&G sector is also in decline. Recent, and possibly sustained, falls in the oil price render offshore production uneconomic compared to adequate low cost onshore resources and the rise of the 'fracking' process for onshore gas. Industry sources believe that the rapid advance of offshore technology peaked in the 1990s and has slowed very considerably. The whole (land and marine) oil sector has been driven by global dependence on fossil fuels as the main resource to supply a burgeoning energy demand. Many companies have employed successful business models and made their fortunes. The economic and political drivers have been with them. Others have been attracted to the sector by its successes but have not had the skills, or the luck, to flourish.

In 2015, the O&G sector has achieved maturity as the world approaches what is believed to be the 'peak oil' event. Pressure grows for emissions restraint and alternative sources of clean energy. Notwithstanding this, and in spite of efforts to move to new energy technologies such as renewable electricity, the use of fossil fuels continues to dominate energy supply and is forecast to continue to do so (well in excess of 50%) for the next fifty years or so. An as yet undetermined transformational technological event, perhaps in renewable and energy storage technologies, might possibly change this equation but current forecasts anticipate continuing dominance of fossils sourced primarily from terrestrial areas. The economic factors are, though, not the complete picture. Geopolitical factors have played a hugely significant role in O&G markets and will continue to do so. Oil has been used as a weapon by major producers to exploit their resources to the full and to punish those states they do not agree with. Wealthy states with smaller resources

have therefore acted to exploit their own, even at uneconomic rates, for the purposes of energy security. Poor developing states have been anxious to develop any easily recoverable reserves to generate economic growth and foreign exchange. These will include the more accessible offshore resources.

7.1.1 The Offshore Oil and Gas Sector in the Development of Blue Growth

Although the offshore O&G industry may be at or past its peak, its products (not only fuels, but also e.g., synthetic materials) still will be necessary for the development of marine economic activities. In any case, its true value to Blue Growth is what it bequeaths at many levels. The successful offshore operators have established technologies, infrastructure and operational skills of enormous value to the Blue Growth sectors while, so far, demonstrating little appetite for diversification themselves. The O&G majors are among the largest multinationals in the world with significant capital to invest, many have started small preliminary investment in renewables but most have pulled back from serious participation. A few have gone further, like BP Solar or Statoil in the development of floating wind (Xing et al., 2014). However, with the depletion of traditionally exploited fields a new factor will enter into force in the short term: decommissioning. In the North Sea alone, 7% of the existing facilities are in the decommissioning process, and it is estimated that over the next 30 years this process will affect to 500–690 additional infrastructures (RAE, 2013).

With all this in mind, the great resource transferability from the O&G industry to the new Blue Growth sectors is clear, being:

- Infrastructures,
- vessels,
- technologies,
- operation procedures,
- human skills,
- supply industries and
- financial resources.

7.2 Market

7.2.1 Products

The need for energy has been the principal driver for the development of the O&G industry. While fuels needed by transport activities are the

main oil products, gas is widely used in electricity generation and heating processes. However, O&G products and by-products have a wide applicability in day-to-day lives as they are used, among others, as raw materials for pharmaceuticals, chemicals, plastics, lubricants, waxes, tars, synthetic clothes, rubbers, paint or photographic films (WOR, 2014).

7.2.2 Market Trends

These are not good times for the O&G market. Imbalances between supply and demand, still tangible effects of the financial crisis, enforced environmental policies, changing consumer preferences or the development of more efficient transport systems have severely hit the industry, particularly in developed countries. However, and despite its marked and sustained slowdown, developing countries economies mean that global O&G consumption continues to increase, giving as a result two general global trends (Mitchell et al., 2012; BP, 2015):

- Non-OECD countries: Growth markets. Developing economies (mainly China) are responsible for the net growth in global consumption. However, these economies are facing an important deceleration, which is being reflected as a slowdown in the consumption growth rates of the sector.
- OECD countries: Non-growth markets. Opposite to developing economies, the O&G consumption rates in the OECD economies remain stagnant or even declining. Noteworthy in this regard are the cases of Japan and the EU, which have suffered, respectively, the largest O&G consumption declines over the last decades.

7.2.3 Prices

Hydrocarbon products are not common trading goods and complex factors influence their prices. Traditionally, their prices have been determined by the fundamentals of supply and demand, being directly influenced by factors like weather, changes in supply/demand patterns or the supply capacity of the producing countries. However, geopolitical and speculative factors have become of special relevance over the last decade. In geopolitical terms, the control over the production, distribution and prices provides economic and political power. Following the opening of the sector to financial markets, O&G products have become assets of great interest, strongly subjected to

speculative interests. Although these factors are strongly interconnected, their individual influence on prices varies depending on specific political and economic situations or interests. As a result, prices in the sector are extremely volatile and unpredictable (NRCan, 2010).

7.2.4 Future Supply and Demand Gaps

As finite resources, existing O&G reserves can't meet the growing demand for energy in perpetuity. Disagreements exist between those who affirm enough reserves for the decades ahead, and the critical voices that warn about the near depletion of stocks (Owen et al., 2010). Considering the industry as a whole (onshore + offshore) both the discovery of new reserves (e.g. deeper offshore fields) and the development of non-conventional exploitation techniques (e.g., fracking, tar sands) will increase the availability of the resource, extending its potential supply capacity over time. However, these new reserves and non-conventional techniques are characterised by their higher exploitation costs. Therefore, the inability of the sector to commercially exploit its resources at prices assumable by the global economy may be a more crucial determinant, rather than the amount of reserves themselves (Owen et al., 2010). This might be of particular importance for offshore activities in which the trend towards exploiting even more hostile and remote areas implies a huge increase in operational costs. This may result in making them even economically unfeasible. In addition, the 2015 report by the UN Intergovernmental Panel on Climate Change (IPCC) clearly states that significant climate change will occur from carbon emissions before known reserves are exhausted. This has led many NGOs to campaign for a policy of *"keep the oil in the ground"*.

In addition, the O&G industry faces increased competition that can influence its future supply-demand trends (Mitchell, et al., 2012). In terms of intra-sectoral competition (i.e., Oil vs. Gas), the oil sector has largely relied on the transportation market. Lower prices of gas and improved air quality can be a driver for the development of gas-fuelled engines and encourage its replacement of oil as a principal fuel. On the other hand, the growing pressure from new fuels, new energy supply types and users requiring alternative non-fossil energy types, may further decrease the demand for O&G products (new biofuels and materials; electric vehicles; environmental protection policies; diversification of energy sources, e.g., renewables).

7.3 Sector Industry Structure and Lifecycle

7.3.1 Lifecycle

Although for the following decades O&G will remain as the main supplier for the global energy demand, the decline affecting the sector is particularly relevant for offshore activities. Following the depletion of traditionally exploited shallower fields, the production at deeper and more hostile areas presents important economic barriers. Even more significantly, the new non-conventional exploitation techniques (e.g., fracking) can redirect the focus of the industry towards onshore activities to the detriment of offshore production.

7.3.2 Industry Sectors and Segmentation

Depending on the processes involved, the O&G industry is divided into *upstream* (exploration, drill wells, production), *midstream* (transportation and storage) and *downstream* (refining and marketing) activities. Firstly, only upstream and midstream activities relate to offshore activities. And secondly, downstream processes are always onshore activities and therefore do not offer interesting alternatives for Blue Growth or potential combinations with other marine economic activities. Thus, considering the scope of this book, only upstream and midstream sectors activities will be considered (Table 7.1).

Table 7.1 Sectors and segments of the O&G industry

Sub-Sectors	Segments
Upstream	Major Companies
Search and exploration of resources, well drilling and extraction of raw materials.	Fully integrated: cover all the facets of O&G industry (upstream-midstream-downstream). Exploit large proven reserves, which require at the same time greater investment (as are also their returns).
Midstream	Small Companies
Transportation (pipelines, LNG/oil tankers) and storage of extracted raw materials.	More versatile, normally focused on exploration and production activities. Go after opportunities discarded by major companies, e.g.: (i) acquiring and exploiting depleted fields trying to squeeze some extra production at lower cost; (ii) exploring in areas where the probability for large discoveries is low; or (iii) operating in areas with uncertain fiscal and regulatory regimes. Invest just enough to reduce uncertainty.

7.3.3 Horizontal and Vertical Integration

Major oil companies usually have a fully integrated structure (vertically and horizontally). Given their huge resources they cover the whole O&G supply chain, from exploration and production of new reserves, to transportation, and, to the final refining and sale to the consumer (upstream-midstream-downstream). On the other hand, small companies do not have enough resources (or interest) to cover the entire supply chain. Usually they develop their activities in very specific segments of the industry (e.g., geophysical surveys, activities exclusively focused on production or transporting) and sell their products/services to third parties of the supply chain. Finally, mergers and acquisitions are common in the industry, so the release or subcontract of certain activities are a frequent practice of oil companies (horizontally within the different segments and vertically along the supply chain).

7.3.4 Centres of Activity

Currently, more than 600 active offshore extraction platforms exist in the EU-28, a value that significantly increases if those located in Norwegian waters are considered. The European offshore production constitutes 9% and 13.8% of the total O&G consumption, respectively. Therefore, the offshore production of hydrocarbons represents an important energy resource for Europe (JRC, 2015). Figures 7.1 and 7.2 show the distribution of the major O&G reserves and their associated infrastructure in the studied basins.

In the *Atlantic basin*, most of the exploration and production is developed in the *North Sea*. Practically all of the oil and more than 80% of the gas produced in Europe are produced by countries bordering the area (i.e., Norway, UK, Denmark, the Netherlands and Germany). Undeniably Norway, and the UK to a lesser extent, are the leading countries in terms of production. This is clearly reflected by the greater number of reserves and development of infrastructures within their territorial waters (Figure 7.1).

Compared to the North Sea, offshore production in the *Baltic* seems minimal. Production activities mainly develop along the Polish coast and represent only 0.1% of the total offshore production (Figure 7.1). However, this basin plays a very important role in strengthening the energy security of the EU. With a length of 1,224 km and a combined transport capacity of 55 bcm/yr (27.5 bcm per line), the Nord Stream twin pipeline crosses the Baltic Sea serving as a connection between the vast Russian gas reserves and the European markets (Nord Stream, 2014).

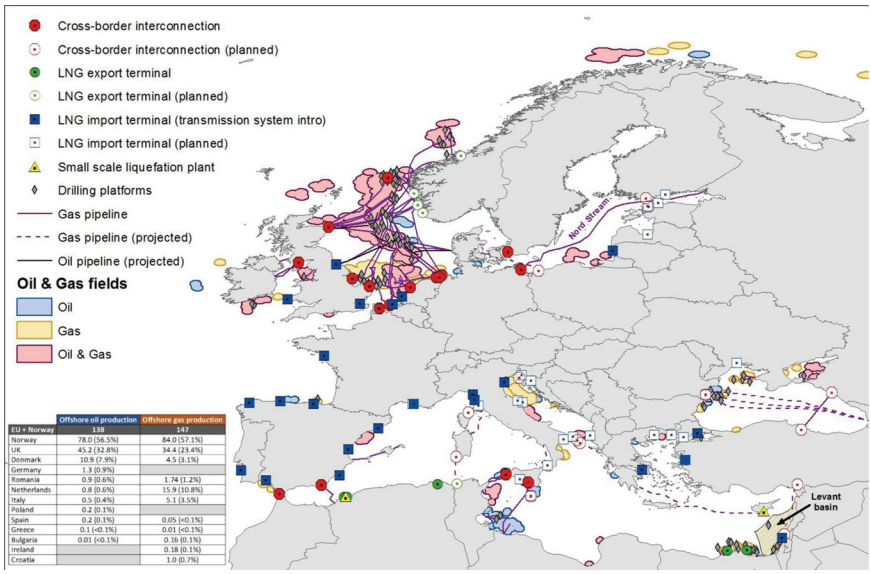


Figure 7.1 Distribution of main Oil and Gas fields and associated infrastructure in the Atlantic, Baltic and Mediterranean basins (Authors' compilation based in: ENTSOG, 2015; Lujala et al., 2007). Offshore oil and gas production values are given in million tonnes (JRC, 2015).

In regard to the European territories of the *Mediterranean*, traditional production areas have been located in Spanish, Greek, Maltese and Adriatic waters (mainly Italian). In this latter case, of special attention is the increase in the offshore production of Croatia. Although these activities can improve the energy self-sufficiency of the country, many critical voices warn about the danger to tourism from potential accidents as it is a tremendously important sector for the economy of the country. In any case, the main production areas in the Mediterranean are outside the territorial seas of the EU, being especially important the North African coast and the recent discoveries in the eastern Levant basin. These latter findings, partially located in Cypriot waters, have enabled the cooperation between the EU and some eastern Mediterranean countries (e.g., Israel, Lebanon). The agreements relate to issues such as, optimisation of exploitations, development of infrastructures, access to European markets, or pricing. Among the regarded options, the construction of the Cyprus-Greece pipeline or the building of a LNG terminal in Cyprus can be highlighted (EC, 2013). Romania and Bulgaria on the one hand

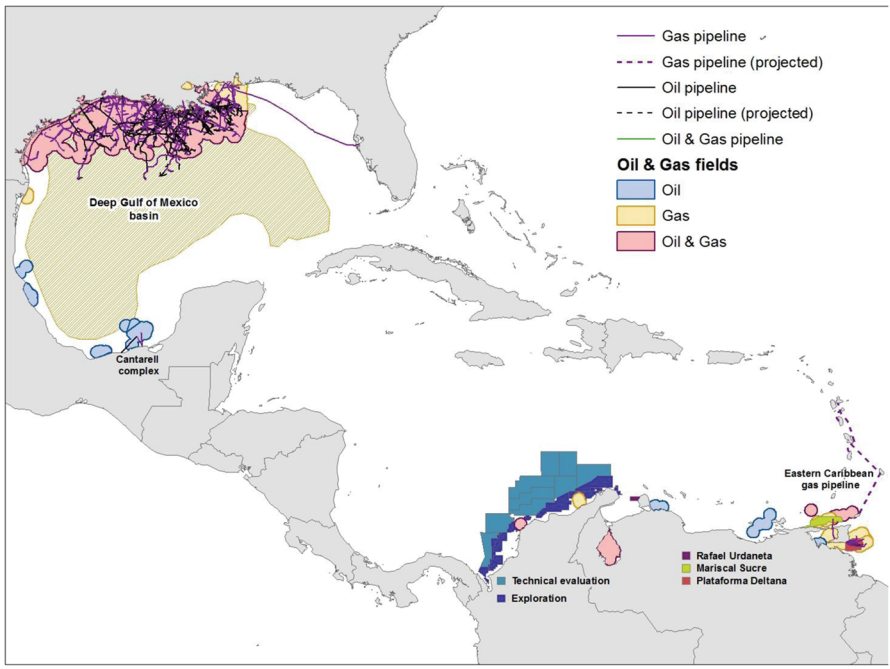


Figure 7.2 Distribution of main Oil and Gas fields and associated infrastructure in the Gulf of Mexico and Caribbean basin (Authors' compilation based in: ANH, 2016; BOEM, 2016; Lujala, et al., 2007; Petróleos de Venezuela SA; Theodora.com).

(intra-EU) and Turkey and Ukraine (extra-EU) on the other, have been the main hydrocarbon producers in the *Black Sea*. Historically, countries bordering the Black Sea have shown little interest in the exploitation of their massive energy resources. Importation (mainly from Russia) has been proven as an easy and cheap option for them. However, changes in the energy markets, the discovery of new reserves in the Bulgarian, Romanian and Turkish coasts or political tensions with Russia, are strengthening the development of offshore production in the region.

Finally, with countries like Mexico, the US, Colombia Venezuela or Trinidad and Tobago, the *Gulf of Mexico and the Caribbean Sea* have major actors in the global energy sector (Figure 7.2). However, most of these resources are outside the territorial waters of the EU or its associated overseas countries territories. Thus, the oil and gas activities carried out in the region may be of less interest for the development of EU's Blue Growth strategies.

7.3.5 Types of Ownership

In the same way that the demand for O&G presents two differentiated patterns (OECD and non-OECD economies), the ownership of O&G reserves also shows two main actors: private companies and National Oil Companies (NOCs). In any case, given the importance of the energy sector for the world economies, unregulated private companies do not exist. Even in the most developed economies, where O&G is supplied by private companies, the sector is strongly influenced by government policies (e.g., subsidies on exploitations and transport, taxes to consumption, price manipulation...).

Private companies have a primary objective to make profits for their shareholders. Typically, they exploit and produce their resources more quickly than NOCs, 10–12% depletion rates, compared to 3–5% for NOCs, (Mitchell et al., 2012). While their resources and infrastructure have a global coverage, their headquarters are normally located in developed economies and direct their production to competitive markets (OECD).

Although NOCs share about 86% of proven reserves, their production rate is comparable to that of private companies (55% of the total). Apart from their national economies, their main customers are located in emerging economies (non-OECD). NOCs normally belong to countries with a high economical reliance on their O&G exports. Hence, their production and reserve exploitation policies are highly conservative in comparison to those of private companies. The protectionism degree of governments towards their NOCs, closely relates to the diversification of their economies. As a result, there exist two types of NOCs (EIA, 2016). The *NOCs organised as corporations* have strategic and operational autonomy. Although mostly controlled by governments' interests, part of their shares are publicly traded and subject to private funding (e.g., Petrobras, Statoil, Gazprom). Thus, they are subjected to the rules of the Stock Exchange, and are characterised by their commercial objectives and income generation. The *NOCs that operate as an extension of government* are aimed to support national policies, both strategically and financially (e.g., Pemex, Saudi Aramco, Petróleos de Venezuela). Their objectives do not directly relate to the markets, as they seek to boost the national and foreign objectives of their countries (e.g., offering lower prices to domestic consumers or generating long term incomes for their economies). In any case, operation agreements between both types of companies (privates and NOCs) are a common practice in the sector that allows a joint venture arrangement where private companies operate NOC owned reserves.

7.3.6 Rules and Regulations

Since it is a source of important government revenue (e.g., by means of taxation, awarding of exploitation licenses, increased GVA, etc.), the O&G industry is crucial for the economies of producing countries. Regulations are applied to the economic activity itself and the industry is also subject to strong requirements on environmental safety. All this complexity is, at the same time, the main cause for investor's reluctance. They opt to invest in countries with favourable regulatory frameworks. Therefore, regulation can become a double-edged sword, as both strict and lax regulations may impair the economic interests of producing countries. As a result, the regulation in the sector is strongly influenced by constant challenges and opportunities in order to maintain a balance between national interests and concessions to the private sector (e.g., changing fiscal regimes, socio-political and environmental sensitivities, etc.). Annex 7.1 shows the main regulations affecting the sector in terms of economic activity, environmental protection and liability and compensation.

7.4 Working Environment[1]

7.4.1 Economic Climate

As already observed, economic and geopolitical factors have a major influence on the performance of this sector. The slow recovery of major economies (e.g., Europe, Japan, China) and current political conflicts in the Middle East and Russia-Ukraine (together with the sanctions imposed by the EU and US), fuel the mistrust of markets in the industry. As a result, the industry has to face an uncertain economic climate (Hays, 2015), in which producer countries adopt different response strategies.

NOCs are an important support for their economies. As an example, PEMEX revenues have accounted approximately for 35% of the Mexican federal government's budget, and PDVSA is the main company sustaining the Venezuelan economy. Therefore, the decline in demand and prices can cause a fatal impact in the socio-economic development of these countries. Thus, the attraction of foreign investments is part of the solution to get cash in both cases (e.g., potential denationalisation of certain fields, exploitation

[1] In general, the information provided in this section refers to the Oil and Gas sector as whole (inland + offshore activities). However, the main European Oil and Gas producers develop their activities at sea. Thus, at least for European countries these figures can be considered fairly representative of specifically offshore activities.

agreements, sale of international assets...). In the case of European private companies, the ageing of their reserves is an additional factor to be considered. Waiting for favourable regulatory and economic changes, these companies have opted to avoid or minimise new investments.

7.4.2 Employment, Skills and Migration

Figure 7.3 shows the direct employment created by the sector in some of the considered countries[2]. It provides a picture of the most important countries in the sector and its relative importance to their national economies: countries with higher production capacity, are those generating a greater number of direct jobs in the sector. The importance of the industry in terms of employment relies on its ability to create indirect employment. In the North Sea alone, it is estimated that each direct employment in the sector induces up to 7.5 other indirect jobs (ECORYS, 2013).

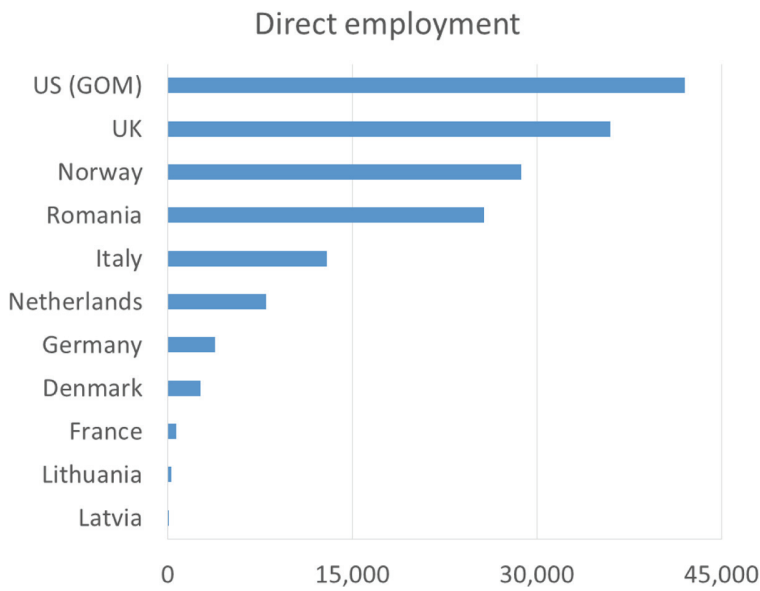


Figure 7.3 Direct employment derived from Oil and Gas exploration activities.

Source: EUROSTAT, 2016; Quest Offshore, 2011.

[2]The data in this section must be considered as indicative as:

- it has not been possible to find data for all the countries involved in offshore activities.
- depending on the sources, direct employment data can vary significantly.

In the coming years, skill shortages will be one of the main problems to be faced by the sector. The rejuvenation of the workforce (added to a poor transfer of knowledge), the retirement of experienced workers, the poor update on technological advances, or strict immigration laws that prevent the access to global talent are among the main causes for this shortage. Much of the expertise required in the sector relates to fields such as science, technology, engineering or mathematics (STEM). The industry is a highly male dominated industry and to balance the lack of skills, O&G recruiters are increasingly focused on the incorporation of women into the sector (Hays, 2015). Companies are increasingly recognising the high quality of women in STEM and they have an increasing presence in the workforce.

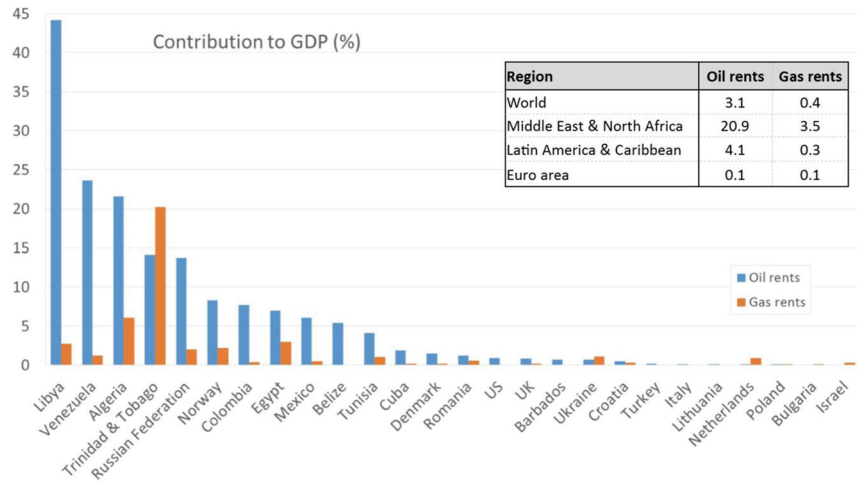
Regarding the migration and mobility of workers, European companies rely principally on their local workforce (Hays, 2013). Europe is characterised by its smaller reserves and by an industry dominated by private companies. These companies commonly operate at the global level, developing much of their production out of European territorial waters and favouring the displacement of workers outside their countries of origin. In addition, the high skills of its workforce can act as additional drivers for the mobility of European workers.

7.4.3 Economic Indicators

7.4.3.1 Contribution to GDP

Figure 7.4 shows the contribution to GDP of the rents derived from the extraction of hydrocarbons in the producing countries around the studied basins. Despite exceptions (e. g., Trinidad and Tobago, Ukraine, Netherlands, Israel), incomes derived from the exploitation of oil exceed those obtained through gas exploitation. Probably this is due to the fact that oil has been traditionally a more intensively exploited and marketed resource than gas, and consequently, more heavily taxed. However, it is likely that this pattern will change in the future: the depletion of oil reserves, along with changes in the preferences of the markets (lower prices of gas, replacement of oil as a primary fuel in transport) can help the expansion of the gas sector and increase the amount of rents collected by producing countries.

Driven by their higher amount of reserves and the lower diversification of their economies (a probable consequence of the former), Caribbean and North African countries are those with a higher reliance on the Oil and Gas sector.



Region	Oil rents	Gas rents
World	3.1	0.4
Middle East & North Africa	20.9	3.5
Latin America & Caribbean	4.1	0.3
Euro area	0.1	0.1

Figure 7.4 Contribution of O&G rents to individual and regional economies.

Source: World Bank, 2015.

7.4.3.2 Wages

Exceeding a global average of $81,000 annually, salary is one of the main attractions for workers in this sector. The countries bordering the North Sea, the US, Colombia and France are at the top of the list, exceeding that average for either their local or imported workforce (Hays, 2013).

In contrast to Norway where salaries of local workers may be up to 60% higher, the remainder of the North Sea countries, US and France present a balance in the wages for both types of workers. These cases should be considered exceptions and indicative of their highly skilled local workforce. In the rest of the countries the salaries of foreign workers are significantly higher, which may be due to two main reasons:

- The allocation to foreign subsidiaries or exploitations of workers from private US and European companies.
- Attempts to attract talent by countries with much production capacity but with a lack of skilled labour.

The bonuses received by the workers are another important aspect to be considered in relation to wages. Companies commonly offer incentives in order to ensure and maintain their skilled workers. Almost 80% of the staff in North Africa and South and North America receives some kind of bonus, while in Europe this value drops to 60%. Bonuses, health plans, home allowances or retirement plans are among the most common incentives (Hays, 2013).

7.4.3.3 Export potentials

Table 7.2 shows major O&G exporting and importing countries. At the EU (+ Norway) level, the only countries with a certain gas export potential are Norway and the Netherlands. In fact, despite the production activity developed by some Member States, the EU as a whole, is a net energy importer. Outside its territorial waters, the Caribbean and Mediterranean basins are those with a higher export potential. In the Caribbean, the development of new offshore exploitations can strengthen the role of the existing exporting countries of Mexico, Venezuela and Trinidad and Tobago. In this latter case, the construction of the Eastern Caribbean Gas Pipeline which will ensure the supply of gas from Trinidad and Tobago to the Eastern Caribbean Islands, will reinforce its role as gas supplier in the region. The recent discovery of huge gas reserves in the Eastern Mediterranean, not only increases the production capacity of the basin (mainly developed in North Africa) but also the export potential of the Eastern Mediterranean countries. In this sense, the agreements signed by the EU and these countries (e.g., Israel), involve a series of advantages for the EU in terms of imports-exports, which might be helpful to ensure its energy security.

7.4.4 Infrastructure and Support Services

Given its complexity and the risks involved, the oil and gas industry requires a large amount of supporting services. Although some large companies integrate these services within their structures, contracting third-parties for support services is a common practice in the sector. Following the NACE classification of economic activities, these services include a variety of

Table 7.2 Top ten of exporter and importer countries

Crude Oil		Natural Gas	
Net Exporters (Mt)	Net Importers (Mt)	Net Exporters (bcm)	Net Importers (bcm)
Saudi Arabia (271)	US (442)	Russia (203)	Japan (123)
Russia (239)	China (269)	Qatar (121)	Germany (76)
Nigeria (124)	India (185)	Norway (103)	Italy (62)
Iraq (119)	Japan (179)	Canada (54)	Korea (53)
UAE (118)	Korea (128)	Algeria (45)	China (49)
Kuwait (103)	Germany (93)	Turkmenistan (45)	Turkey (45)
Venezuela (93)	Italy (74)	Netherlands (40)	France (43)
Canada (90)	Spain (60)	Indonesia (35)	UK (39)
Angola (84)	Netherlands (57)	Australia (26)	US (37)
Mexico (66)	France (57)	Nigeria (22)	Spain (30)

Source: IEA, 2014.

additional industries, which among others, relate to shipping, transport, port services, R&I, construction and engineering, wholesale or health and safety (EUROSTAT, 2008).

7.5 Innovation

7.5.1 Innovative Aspects and New Technology

The depletion of the more accessible offshore reserves (<400m depth) has pushed the search for hydrocarbons towards deepwater (∼1500m) and ultra-deepwater (>1500m) areas. The use of the most advanced geophysical exploration techniques has enabled the detection of vast deposits at depths of up to 12 km. According to recent estimates, these deepwater/ultra-deepwater deposits account for more than 50% of the newly discovered larger offshore fields (i.e. fields with an estimated minimum recoverable reserve of 170 billion barrels). However, the high costs of production at such deep locations, puts in risk the economic viability of these deepwater/ultradeep water reserves (WOR, 2014).

In this sense, the development of subsea completion systems offers a series of advantages and alternatives to the traditional use of large platforms. Integrating several components for the processing of oil and gas (compressors, pumps, and separators), these systems are directly deployed onto the seabed, and underwater robots connect the different components to form large production ensembles (Devold, 2013). Among the advantages provided by these subsea systems, the following are innovation areas currently being explored:

- Simplification and efficiency improvement of the extraction, cleaning and processing processes: improves the performance of pumps and compressors and avoids the need for pumping to drilling platforms.
- Reduction of the amount of offshore production infrastructures.
- Increase of the exploitation radius: it is now possible to deploy within a wider radius several wells which pump to a common production station.
- Reduction of operating costs.

Although several fields operated by these subsea systems already exist (e.g., Gulf of Mexico, South America, Norway), its full commercial development still requires a number of technological innovations. In traditional platforms the maintenance of production infrastructures (pumps, compressors, etc.) may be relatively simple. However, these tasks turn highly complex when working subsea and at such great depths. To solve these issues, much of

the innovation work in the offshore industry is focused on the development of robust, highly reliable and commercially operative submarine production systems (WOR, 2014).

7.5.2 Decommissioning and Cross-Sectoral Opportunities

Decommissioning is the dismantling process of O&G infrastructures once the exploitations reach the end of their lifecycle. Given the rapid decline of the reserves in the North Sea, most of the information on decommissioning relates to that area. It is estimated that all of the existing facilities will require decommissioning over the next 30 years (RAE, 2013). These operations will not only require strong economic investment (estimations in the North Sea exceed £30billion over the next 30 years) but also great human and technical capital. In any case, it can be expected that with the future depletion of existing exploitations, decommissioning will also acquire an increasing importance all over the world. However, it presents some interesting characteristics and possibilities for Blue Growth:

a) From a strict point of view, decommissioning is not considered a sector within the O&G industry. However, as a result of the decline of the sector, it may emerge forcefully as a new offshore and highly technical activity that may absorb and replace the loss of highly skilled employment from E&P activities.
b) Development of MUS/MUP activities: existing offshore O&G platforms can turn into valuable assets, as they can provide the infrastructure needed for the combination of maritime activities. However, based on previous experiences from the Gulf of Mexico (BOEM, 2007) the success of these combinations may vary greatly.
    b.1) Active platforms: apart from being the owners of the platforms, oil companies assume elevated risks and costs in their production activities. For this reason, it cannot be forgotten that in any combination including the use of any active facility, the interests of the O&G industry will always predominate against additional industries. Thus, oil companies may be reluctant to combine and share their infrastructures with sectors that add risks to their operations without obtaining any direct benefit (e.g., aquaculture, immature renewable technologies). As an exception, the combination with wind energy can arise more interest, since the combination of these fully developed technologies can provide short term benefits to all parties.

b.2) Obsolete platforms: this seems to be the most suitable option for the combination of activities, since it reduces either the power positions between industries or the risks associated with the oil industry (e.g., spills, contamination of farmed species, etc.). It can also be an incentive for oil companies, which can consider it as an option to delay and reduce the expenses of the future decommissioning of their infrastructures (rental agreements, leases, etc.). However, this option also poses a series of challenges, related mainly to the regulatory framework. Despite some exceptions that enable derogation (e.g., sub-structures weighing more than 10,000 tonnes), most of regulations on decommissioning dictate the complete removal of all the infrastructures once they become obsolete (e.g., UNCLOS Article 60 (3); OSPAR Decision 98/3). Therefore, the possible re-use or reconversion of obsolete platforms must be regarded as a case-by-case study of the available options and applicable regulations.

7.6 Investment

Government incentives, public donors (e.g., EU) and private investors are the main funding source for oil companies (ECORYS, 2013).

The O&G industry is very lucrative not only for companies, but also for Governments, who receive substantial revenue through the taxation derived from the whole sector chain (from producing companies to final consumers). To ensure these revenues and attract and retain the investment in the sector, Governments often provide support to oil companies (Table 7.3).

Funding through their own reserves, private equity funds, bank loans or bonds are the main forms of private investment. While government investments seek to secure revenues for the development of their national economies, private investments try to maximise benefits. Thus, some private investors may opt for higher risk investments (in more hostile areas or new explorations), which provide the opportunity for greater benefits.

7.7 Uncertainties and Concluding Remarks

Although the dominance of the O&G industry as the principal energy supplier is expected to continue in the future, its offshore activities are in decline. The depletion of the more accessible reserves has driven the search and

Table 7.3 Common types of Government Interventions in Energy Markets

Intervention Type	Description
Natural resource access	Policies governing the terms of access to domestic onshore and offshore resources (e.g., leasing)
Cross-subsidy	Policies that reduce costs to particular types of customers or regions by increasing charges to other customers or regions
Direct spending	Direct budgetary outlays for an energy-related purpose
Government ownership	Government ownership of all or a significant part of an energy enterprise or a supporting service organization
Import/export restriction	Restrictions on the free market flow of energy products and services between countries
Information	Provision of market-related information that would otherwise have to be purchased by private market participants
Lending	Below-market provision of loans or loan guarantees for energy-related activities
Price control	Direct regulation of wholesale or retail energy prices
Purchase requirements	Required purchase of particular energy commodities, such as domestic coal, regardless of whether other choices are more economically attractive
Research and development	Partial or full government funding for energy-related research and development
Regulation	Government regulatory efforts that substantially alter the rights and responsibilities of various parties in energy markets or that exempt certain parties from those changes
Risk	Government-provided insurance or indemnification at below-market prices
Taxes	Special tax levies or exemptions for energy-related activities

Source: World Bank, 2010a.

exploitation of hydrocarbon resources towards more remote and therefore, more expensive areas. This, together with the development of new onshore techniques and the general fall of prices, can turn offshore activities economically unfeasible. While the big European companies operate at the global scale, the production in European territorial waters accounts for 9% and 13.8% of the total oil and gas consumption of the EU, respectively. Within territorial waters, most of the activity is developed in the North Sea, being Norway and UK by far the principal producers. The Caribbean is one of the main producers worldwide and the Mediterranean holds recently discovered enormous deposits. However most of these deposits are located outside the EU's territorial waters. Therefore, the decline of the North Sea reserves may limit even more the supply capacity of the EU and increase the need for importation of hydrocarbons.

In any case, the decline of the O&G sector also presents a series of opportunities and challenges for the development of BG industries, which principally rely on two fundamental aspects of the industry: skills and infrastructure.

- Skills. The extensive working experience in the marine environment, has resulted in a competitive industry which holds a highly skilled workforce. In this sense, the high human skill transferability and the experience dealing with adverse situations (both environmental and financial), are of great interest and a good example for the development of new offshore economic activities.
- Assets. The oil industry has developed and integrated technologies, operational models and equipment adapted to harsh marine environments. These include: vessels (e.g., platform supply vessels, tankers), underwater scanning and surveying methods (e.g., ROVs and AUVs), complex engineering techniques (e.g., floating anchoring systems, deep sea drilling, subsea systems) or personnel trained to work at sea. All these assets are of value for the future development of new offshore industries, especially for those that require large and challenging technical works (e.g., deployment of renewable energy devices, deep sea mining, offshore aquaculture, etc.).
- Infrastructure. The sector has many offshore installations, which could be an important support for BG sectors, and more specifically, for the development of MUS/MPP concepts. However, most of the current marine legislation dictates the dismantling of all the existing infrastructures once they reach the end of their lifecycle. Despite certain exceptions that permit for derogation, decommissioning is an extremely complex process. These difficulties not only rely on the huge financial and technical requirements, but also in the possible environmental and socioeconomic impacts (e.g., pollution, conflicts with fisheries/aquaculture, restrictions on the use of space, ecological impacts). At national levels, the development degree of policies and guidelines on decommissioning, varies depending on the maturity of the O&G industry and the previous experiences of countries. In this way, countries like Norway and UK have regulatory provisions on decommissioning in their legal frameworks. These requirements range from constitutional provisions to specific requirements (World Bank, 2010b). The creation of a common and clear regulatory framework not only will allow operators to know compliance requirements, but it can also set the conditions that will allow the conversion of existing infrastructures. Thus, for the moment,

the reuse for new purposes of an existing O&G infrastructure, will be subjected to a case by case study, in which either the type of infrastructure or the regulatory framework to which it is subject must be considered.

Annex 7.1 – Regulation in the Oil & Gas industry

Economic activities (reserves, licenses, exploration and production…)	EU	• Directive 94/22/EC on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons • Decision 1999/280/EC regarding a Community procedure for information and consultation on crude oil supply costs and the consumer prices of petroleum products • Decision 2003/796/EC on establishing the European Regulators Group for Electricity and Gas • Regulation (EC) 715/2009 on conditions for access to the natural gas transmission networks • Directive 2009/73/EC concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC • Directive 2009/119/EC imposing an obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products • Regulation (EU) 994/2010 concerning measures to safeguard security of gas supply • Regulation (EU, Euratom) 617/2011 concerning the notification to the Commission of investment projects in energy infrastructure within the European Union and repealing Regulation (EC) No. 736/96
	US	• Outer Continental Shelf Lands Act (OCSLA) • Oil and Gas Royalty Management Act • Petroleum Marketing Practices Act
	Mexico	• Ley de Hidrocarburos
	Venezuela	• Ley Orgánica de Hidrocarburos • Ley Orgánica de Hidrocarburos Gaseosos

(*Continued*)

Annex 7.1 Contniued

	Colombia		• Ley 1274 de 2009 por la cual se establece el procedimiento de avalúo para las servidumbres petroleras
	Trinidad and Tobago		• The Petroleum Act • The Petroleum Regulations • The Petroleum Taxes Act
Environmental protection	Regional conven-tions	OSPAR (North East Atlantic)	• Annex III on elimination of offshore pollution sources • Recommendation 2010/18 on the prevention of significant acute oil pollution from offshore drilling activities
		HELCOM (Baltic)	• Annex VI on prevention of pollution from offshore activities
		Barcelona (Mediter-ranean)	• Protocol for the protection of the Mediterranean sea against pollution resulting from exploration and exploitation of the continental shelf and the seabed and its subsoil
		Cartagena (Caribbean)	• Oil spills protocol
	EU		• Directive 2008/56/EC. Marine Strategy Framework Directive • Directive 2013/30/EU on safety of offshore oil and gas operations.
Liability and compensation for damages	International		• International law principles
	Barcelona convention (Mediterranean)		• Protocol for the protection of the Mediterranean sea against pollution resulting from exploration and exploitation of the continental shelf and the seabed and its subsoil • Guidelines for the determination of liability and compensation for damage resulting from pollution of the marine environment in the Mediterranean sea area (not binding)
	EU		• Directive 2004/35/EC on environmental liability with regard to the prevention and remedying of environmental damage • Directive 2013/30/EU on safety of offshore oil and gas operations.

References

ANH (2016). Mapa de Tierras. Agencia Nacional de Hidrocarburos. (http://www.anh.gov.co/Asignacion-de-areas/Paginas/Mapa-de-tierras.aspx).

BOEM (2007). Alternate Uses of Existing Oil and Natural Gas Platforms on The OCS. In: Final Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf. Bureau of Ocean Energy Management (http://www.boem.gov/Renewable-Energy-Program/Regulatory-Information/Guide-To-EIS.aspx).

BOEM (2016). Geographic Mapping Data in Digital Format-Pipelines. Bureau of Ocean Energy Management. (https://www.data.boem.gov/homepg/data_center/mapping/geographic_mapping.asp).

BP (2015). BP Statistical Review of World Energy. 48 pp. (http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

Devold, H. (2013). Oil and gas production handbook. An introduction to oil and gas production, transport, refining and petrochemical industry. ABB AS. 108pp. (http://dspace.bhos.edu.az/xmlui/bitstream/handle/123456789/944/Oil%2Band%2Bgas%2Bproduction%2Bhandbook.pdf?sequence=1).

EC (2013). Implementation of the Communication on Security of Energy Supply and International Cooperation and of the Energy Council Conclusions of November 2011. COM(2013) 638 final, Brussels. 15 pp. (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2013:0334:FIN).

ECORYS (2013). Study on Blue Growth and Maritime Policy within the EU North Sea Region and the English Channel. Annex III B – Sector Analysis – Offshore oil and gas. Rotterdam/Brussels. 23 pp. (https://webgate.ec.europa.eu/maritimeforum/sites/maritimeforum/files/Annex%20III%20B%20-%20Final%20sector%20Analysis%20oil%20an%20gas.pdf).

EIA (2016). Oil: Crude and petroleum products explained. Where our oil comes from. https://www.eia.gov/energyexplained/index.cfm?page=oil_where (last accessed May 2017).

ENTSOG (2015). Transmission capacity map 2015. European Network of Transmission System Operators for Gas (http://www.entsog.eu/public/

uploads/files/maps/transmissioncapacity/2015/ENTSOG_CAP_MAY2015_A0FORMAT.pdf).

EUROSTAT (2008). NACE Rev. 2. Statistical classification of economic activities in the European Community. Eurostat Methodologies and Working Papers, Luxembourg. 369 pp. (http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF).

EUROSTAT (2016). Structural Business Statistics-Main Indicators. Persons employed by NACE Rev.2: Extraction of crude petroleum and gas. (http://ec.europa.eu/eurostat/web/structural-business-statistics/data/main-tables).

Hays (2013). Oil and Gas global salary guide – Review of 3013 outlook for 2014. 36 pp. (http://www.hays.com/cs/groups/hays_common/@og/@content/documents/promotionalcontent/hays_920901.pdf).

Hays (2015). Oil and Gas Global Salary Guide 2015. 44 pp. (http://hays.com/oil-and-gas/SalaryGuide/2015SalaryGuide/index.htm).

IEA (2014). Key World Energy Statistics, 2014. International Energy Agency. 82 pp. (https://www.iea.org/publications/freepublications/publication/key-world-energy-statistics-2014.html).

JRC (2015). Offshore Oil and Gas production in Europe. Joint Research Centre-European Commission. http://euoag.jrc.ec.europa.eu/node/63 (last accessed August 2015).

Lujala, P., Rød, J. K., Thieme, N. (2007). Fighting over oil: A new dataset. *Conflict Management and Peace Science* 24(3): 239–256.

Mitchell, J., Marcel, V., Mitchell, B. (2012). What next for the Oil and Gas industry? London, Chatham House (The Royal Institute of International Affairs), London. 128 pp. (https://www.chathamhouse.org/publications/papers/view/186327).

Nord Stream (2014). Secure Energy for Europe. The Nord Stream Pipeline Project (2005–2012). 139 pp. (http://www.nord-stream.com/press-info/library/).

NRCan (2010). Review of Issues Affecting the Price Crude of Oil. Ottawa Petroleum Resorces Branch-Energy Sector. Natural Resources Canada-Ressources Naturelles Canada, Ottawa. 37 pp. (http://www.nrcan.gc.ca/energy/crude-petroleum/4557).

Owen, N. A., Inderwildi, O. R., King, D. A. (2010). The status of conventional world oil reserves – Hype or cause for concern? Energy Policy 38(8): 4743–4749.

Quest Offshore (2011). United States Gulf of Mexico Oil and Gas Natural Gas Industry Economic Impact Analysis – The Economic

Impacts of GOM Oil and Natural Gas Development on the U.S. Economy. Prepared for the American Petroleum Institute (API) and the National Ocean Industries Association (NOIA). 152 pp. (http://gulfeconomicsurvival.org/pdfs/QuestGOMEconomicStudy.pdf).

RAE (2013). Decommissioning in the North Sea. A report of a workshop held to discuss the decommissioning of oil and gas platforms in the North Sea. Royal Academy of Engineering, London. 15 pp. (http://www.raeng.org.uk/publications/reports?q=decommissioning).

WOR (2014). Oil and Gas from the sea. World Ocean Review. Marine Resources-Opportunities and Risks. 8–51 pp. (http://worldoceanreview.com/en/wor-3-overview/oil-and-gas/).

World Bank (2010a). Subsidies in the Energy Sector: An overview. Background Paper for the World Bank Group Energy Sector Strategy. July 2010. 115 pp. (http://siteresources.worldbank.org/EXTESC/Resources/Subsidy_background_paper.pdf).

World Bank (2010b). Towards Sustainable Decommissioning and Closure of Oil Fields and Mines: A toolkit to Assist Government Agencies. World Bank Multistakeholder Initiative, 186 pp. (http://siteresources.worldbank.org/EXTOGMC/Resources/336929-1258667423902/decommission_toolkit3_full.pdf).

World Bank (2015). World development indicators. http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators&Type=TABLE&preview=on (last accessed September 2015).

Xing, Y., Karimirad, M., Moan, T. (2014). Modelling and analysis of floating spar-type wind turbine drivetrain. *Wind Energy* 17: 565–587.