

Offshore hydrocarbons

Technological progress is enabling production from offshore oil and gas fields at increasingly ambitious depths (3,000 metres). Investment in offshore production is running at around \$100 billion per year, accounting for one-fifth of all investment in oil exploration and development worldwide. However, the global economic crisis that broke at the end of 2008 and the accident involving the Macondo well temporarily disrupted the race to deep offshore technology.

A number of fields were brought into production in Azerbaijan and Venezuela between 1920 and 1930, but large-scale offshore extraction of hydrocarbons really took off in the 1950s, in the Gulf of Mexico. At that time, production platforms were located offshore Texas in water depths counted in tens of metres, and their only purpose was to support the wellhead.

Following the first oil crisis of 1973, governments — and especially European governments — saw it as crucial to boost energy independence against a background of oil-field nationalisations in the Middle East and North Africa, combined with the rapidly rising price of a barrel of oil.

Countries with North Sea coastlines, like the United Kingdom and Norway, then began to develop their reserves in water depths of between 100 and 150 m.

Today, all the leading oil companies are particularly active in offshore development. As they encounter increasing difficulties in accessing new conventional reserves, so they are turning to more complex developments like the deep offshore to deliver growth and boost production.

A consistently high price per barrel for oil enables producers to justify the most advanced, and therefore most costly, technologies required to bring fields into production.

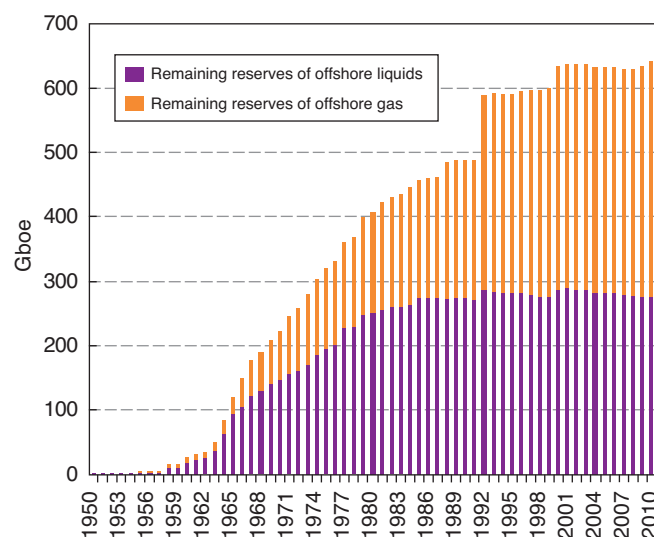
It is also important to underline the very major role played in this market by Petrobras, especially in the Brazilian offshore.

Offshore hydrocarbon reserves and production

In 2010, offshore production regions represented nearly 650 billion barrels of oil equivalent (Gboe) (Figure 1), or 20% of known remaining global oil reserves. In terms of

gas, these regions contain 25% of known reserves and 28% of remaining reserves. Offshore is therefore a non-negotiable imperative for oil companies, but one that presents multiple technological challenges as a result of the water depths and high pressures involved.

Fig. 1 – Trend in offshore oil and gas reserves in Gboe



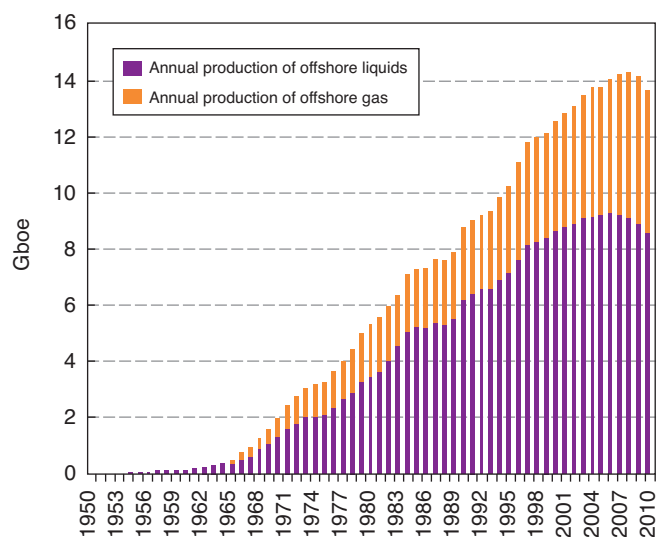
Sources: IFP Energies nouvelles (IFPEN) and IHS Energy

In 2010, the offshore industry produced 23.6 million barrels per day (Mbbl/d), or 30% of global production, and 2.4 billion m³ per day (bcm/d) of gas, or 27% of global production (Figure 2). The proportion is even greater for non-OPEC countries.

After the global economic and financial crisis of 2008, the fall in global demand for hydrocarbons was followed by a 6% decline in offshore oil production relative to 2010. In 2008, offshore oil production was running at 25 Mbbl/d.

Offshore hydrocarbons

Fig. 2 – Trend in offshore oil and gas production in Gboe per year

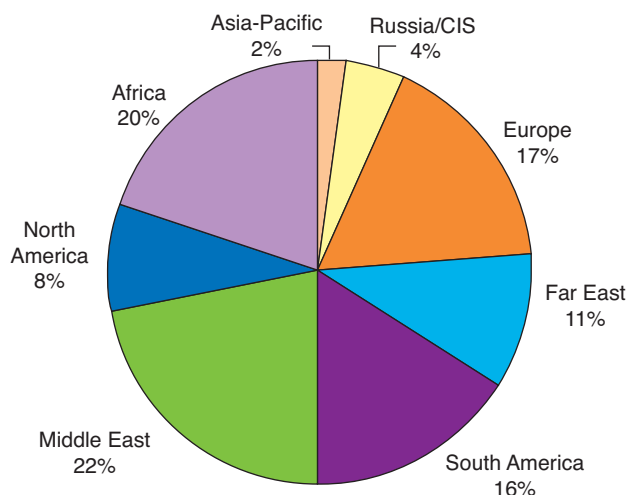


Sources: IFPEN and IHS Energy

In comparison, offshore gas production fell less dramatically and took longer to do so, with figures for 2009 2.4% below those for 2010.

Two regions account for more than 20% of global offshore oil production: the Middle East (22%), where production is concentrated chiefly in shallow depths (less than 200 m) and West Africa (20%), where production is focused on Nigeria, Angola and — more recently — Ghana (Figure 3).

Fig. 3 – Breakdown of global offshore oil production



Source: IFPEN

With its reserves and mature fields, the North Sea still contributes 17% of world offshore production.

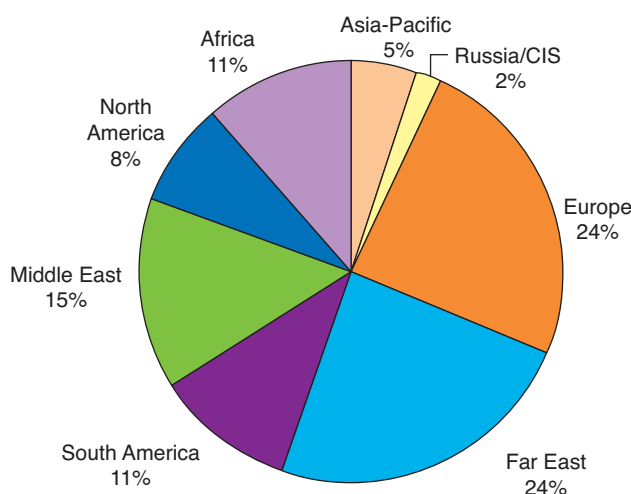
Currently accounting for 16% of global production, South America should see its contribution increase

significantly in future years, given the enormous investment made in production start-up of the major Brazilian pre-salt fields, like Lula.

In terms of gas production (Figure 4), despite falling production levels, Europe (with its North Sea reserves) remains the leading offshore contributor on an equal footing with the Far East.

The Middle East accounts for 15% of production, although this contribution could increase as a result of recent developments offshore Israel and major exploration projects underway in the eastern Mediterranean (offshore Lebanon, Syria, Cyprus and Egypt).

Fig. 4 – Breakdown of global offshore gas production



Source: IFPEN

Development of the deep and ultra-deep offshore

For the purposes of this report, we will define “deep offshore” as those regions with water depths in excess of 1,000 m, and “ultra-deep offshore” as those with water depths in excess of 1,500 m.

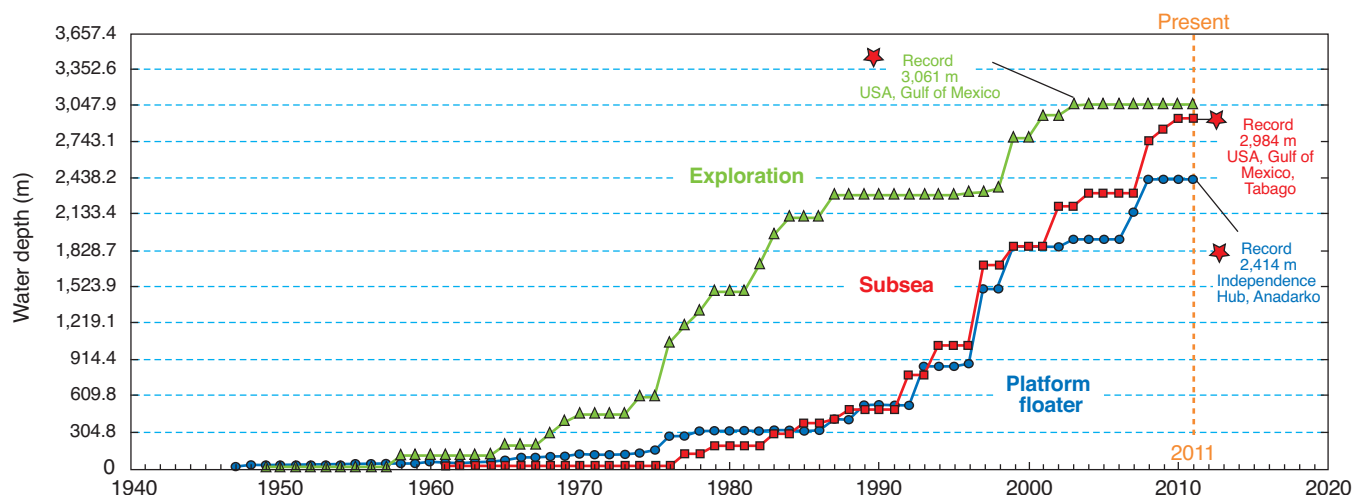
Technological progress in exploration, especially the ability to image those areas below formations that usually act as a barrier (salt, basalt, etc.), and in complex geologies have made it possible to update the assessment of new offshore reserves (Figure 5).

However, these discoveries are increasingly modest in size and are found in deeper and deeper water. Bringing them into development poses significant technological and financial challenges.

It is technologically possible to drill wells in 3,000 m of water to reach very deep reservoirs. The drilling costs involved run to many tens of millions of dollars.

Offshore hydrocarbons

Fig. 5 – Trend in water depth for exploration and development drilling since 1940



Source: Offshore Magazine 2011

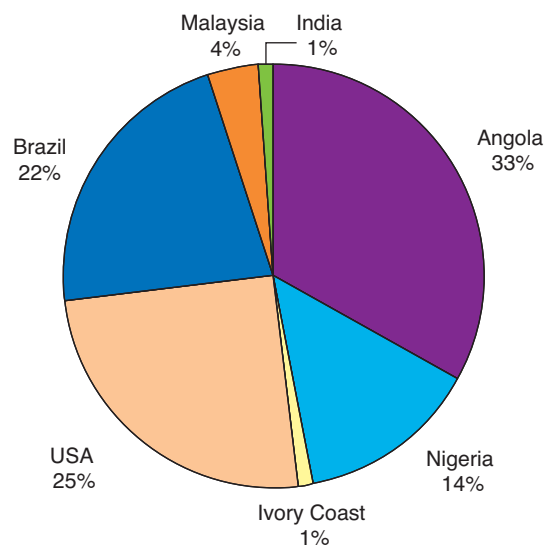
In terms of number of discoveries and future reserves, 450 new fields have been discovered worldwide in water depths of more than 1,000 m. Of these, 38% are in the Gulf of Mexico (USA), 18% are offshore Brazil, 26% are in the Gulf of Guinea (Angola, Nigeria, Congo Brazzaville, Guinea and Ghana) and 13% are in the Asia-Pacific region (Australia, India, Malaysia, Indonesia and China). Discoveries have also been made in Norway, Egypt, Israel, Trinidad & Tobago, Canada and Greenland.

In 2008, oil reserves discovered in water depths greater than 1,000 m were estimated at 72 Gbbl. This figure represents approximately 4% of global reserves. Four countries hold 90% of these reserves (Figure 6): Brazil, the USA, Angola and Nigeria.

The 2.7 Tm³ of gas reserves discovered in depths of water greater than 1,000 m are located in seven countries (Figure 7): Australia (40%), India, the USA, Indonesia and Nigeria (between 8 and 10% each), China and Brazil (5% each).

Oil production in water depths greater than 1,000 m was estimated at 3.2 Mbbl/d in 2008; a figure equivalent to 3% of global production. Nearly half of this production is located offshore West Africa. The production of gas from water depths greater than 1,000 m represents less than 2% of the global figure, with the majority of production currently focused on the USA. Australia began production of gas from water depths greater than 1,000 m in 2011, and given the extent of its reserves, should become a major player in future years.

Fig. 6 – Geographic distribution of oil production in water depths greater than 1,000 m



Source: IFPEN

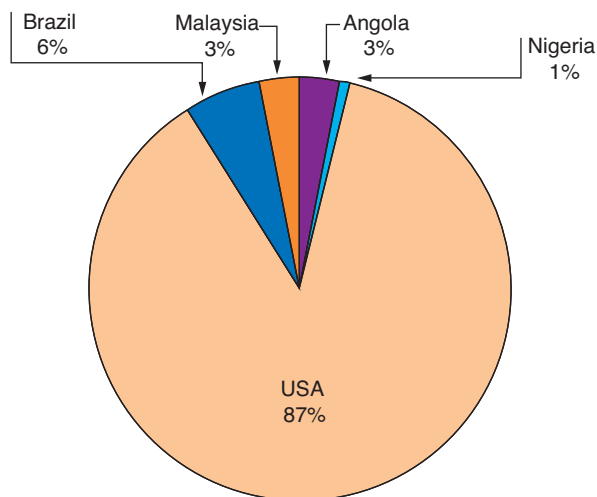
When we look at oil and gas production in blocks of 500 m of water, we can see an acceleration in deep offshore (between 1,000 and 1,499 m) and ultra-deep offshore (> 1,500 m) production in the period from 2005 to 2010.

The volumes produced increased by factors of 3 and 3.5 respectively, whilst production in the block between 500 and 1,000 m of water only doubled.

This trend is expected to continue in the future. Analyst Infield Systems (Figure 8) offers an even more optimistic forecast for production growth in the ultra-deep offshore between 2010 and 2015, quoting a factor of 4.5, compared with a doubling in production for the rest of the offshore market.

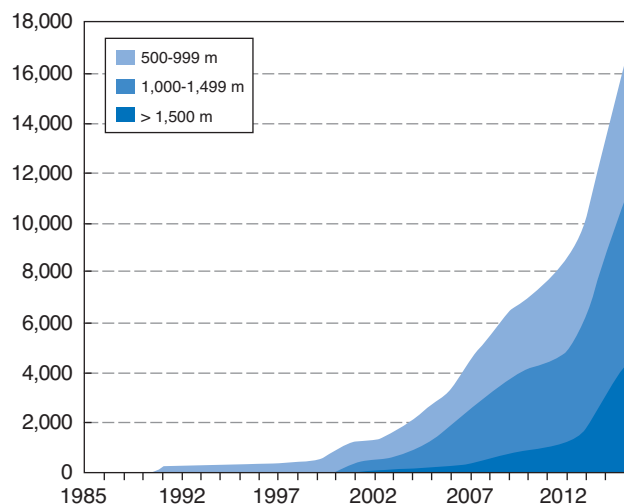
Offshore hydrocarbons

Fig. 7 – Geographic distribution of gas production in water depths greater than 1,000 m



Source: IFPEN

Fig. 8 – Oil and gas production (in Kboed) by block of 500-metre water depth



Source: Infield Systems

Offshore drilling around the world

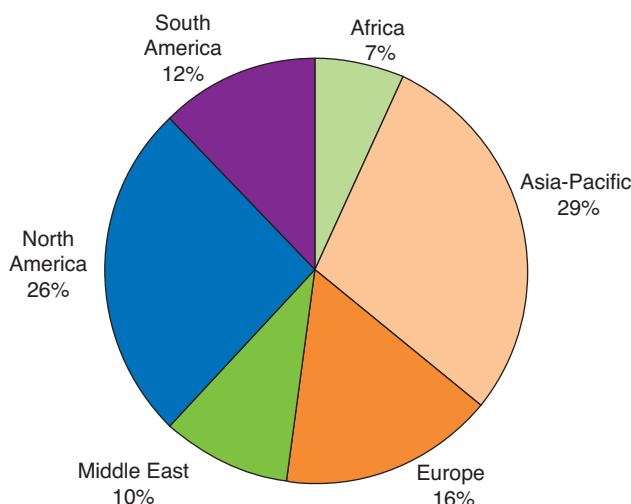
Of the 116,000 wells drilled worldwide in 2011, 3,400 — 3% — were drilled offshore. The 2008 pre-crisis level was 3,500.

Nearly half of global drilling activity is focused on Southeast Asia, with China alone accounting for 13%: the same proportion as the North Sea. With the developments underway in the Gulf of Guinea, Africa accounts for 11% of activity.

As the Brazilian offshore takes off, activity in South America is currently comparable with that seen in the

Gulf of Mexico: 9% of the global total. Then comes the Middle East, where activity is on a par with Russia and the Former Soviet Republics.

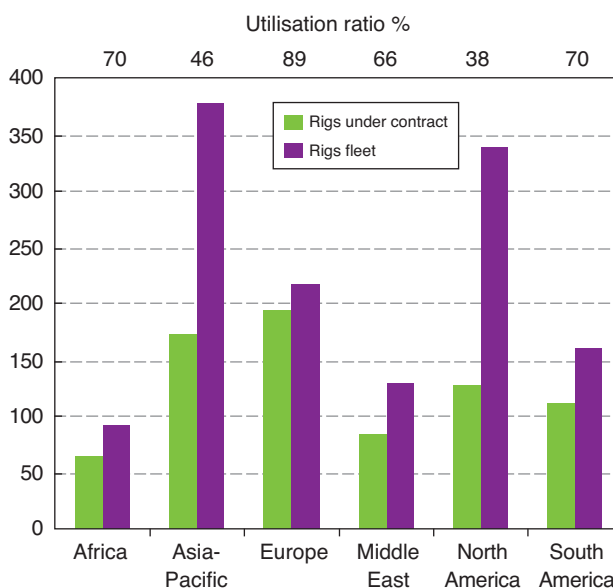
Fig. 9 – Regional distribution of the global fleet of offshore drilling rigs



Source: IFPEN

In September 2011, the world fleet of offshore drilling rigs (jack-up rigs, platforms, submersibles, drilling vessels, etc.) totalled 1,320 units, of which 760 were engaged in drilling around the world (Figure 9), reflecting a usage rate of 58% (Figure 10). The 2008-2009 global financial crisis saw a 15% reduction in both the activity and usage rate of these resources compared with 2008.

Fig. 10 – Usage rate of drilling rigs by region



Sources: IFPEN and Rigzone, September 2011

Offshore hydrocarbons

Today, leasing rates in all regions remain well below those seen before the 2008-2009 crisis. However, there is a visible stabilisation and overall recovery in leasing rates for jack-up rigs (+10%), although leasing rates for the deep offshore and semisubmersibles have declined by 10%.

In the short term, as offshore exploration and production intensify in 2012, it is likely that rig leasing rates will firm up.

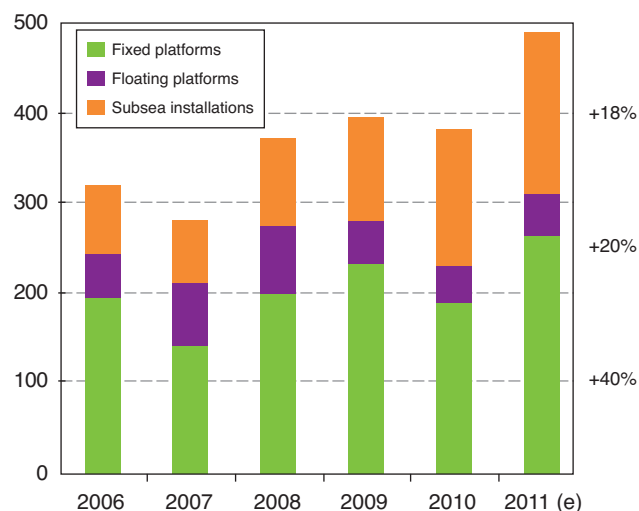
In 2011, the value of the offshore drilling market was estimated at \$38 billion, reflecting relative stability compared with 2010.

Offshore construction around the world

Offshore production involves 17,000 operating platforms, with more than 400 new production facilities (fixed, floating and subsea platforms) being constructed every year.

The number of offshore construction projects has grown by an average of 15% per year since 2005. The main effect of the global financial and economic crisis was to suspend activity in 2010 and moderate the growth of future projects, resulting in the annual rate of increase falling to less than 5% post 2008. However, it is expected that 2011 will have seen a return to growth in the overall number of construction projects (Figure 11).

Fig. 11 – Types of offshore construction 2006-2011



Sources: IFPEN and Offshore Construction Locator

Fixed platforms are used for water depths of less than 300 m, and represent more than 50% of offshore construction projects. This type of platform is used primarily in the Asia-Pacific region and the Middle East.

Floating platforms — semi-submersible and FPSO (Floating Production Storage and Offloading) platforms for the purpose of this analysis — represent only 10% of offshore construction projects worldwide.

Subsea installations link distant field wellheads to production facilities by means of an underwater connection. Since 2006, their use has tripled. They are used particularly for the development of satellite fields close to existing production platforms. They also allow costs to be shared in major regional developments by enabling a single floating structure to service several large-scale fields.

The offshore construction market doubled in size between 2005 and 2008, from \$27 billion to more than \$50 billion. The 2009 crisis broke this trend, with two successive years of decline: -4 and -2%.

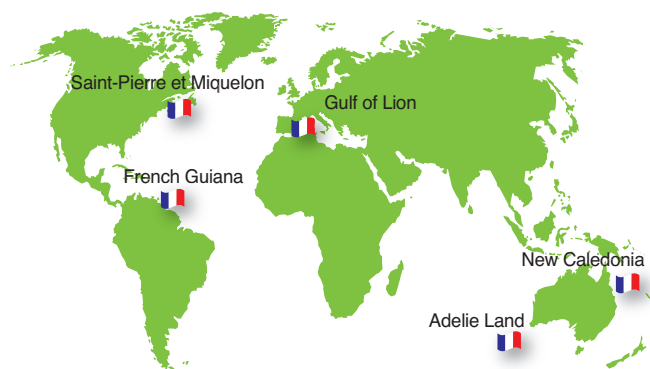
In 2011, the market was estimated at \$56 billion, a revenue level comparable with the pre-crisis situation.

The French deep offshore

At more than 11 million km², the French Exclusive Economic Zone (EEZ) is one of the largest in the world. It covers many oceans and a broad spectrum of geological contexts.

The most promising regions are French Guiana, Saint-Pierre et Miquelon, New Caledonia and Adelle Land (Figure 12). In terms of mainland France, the depths of the Gulf of Lion may offer potential for oil and gas production.

Fig. 12 – Oil-producing potential of the French deep offshore



Source: IFPEN

The potential offered by the French Guiana deep offshore has been known since the 1990s. However, the discovery of the Jubilee field offshore Ghana (where the geology is similar to that of the north-eastern coast of South America) has revived interest in this sector in terms not only of quality, but also of potential deposit size.

Offshore hydrocarbons

This revival of interest was confirmed in September 2011 with the discovery of hydrocarbons by Tullow Oil in the Guyane Maritime licence. Total owns a 25% stake in this licence, which is operated by Tullow.

Located approximately 150 km north-east of Cayenne, the GM-ES-1 well has been drilled in a water depth of just over 2,000 m, and currently extends 5,711 m below sea level.

Given the size of the structure discovered and the possibility of discovering further similar fields, the French Guianan offshore is attracting new interest in terms of hydrocarbon production.

Similarly, the Gulf of Lion is more attractive now than it was just a few years ago. It has geological similarities with the major discoveries made in the Tamar and Leviathan fields offshore Israel and Lebanon, and is benefiting from the success achieved by infrasaliferous exploration offshore Brazil and in the Gulf of Mexico.

The oil production potential of New Caledonia has yet to be fully identified.

Adelie Land seems to offer definite potential for oil, but the terms of the Antarctic Treaty rule out the prospect of any exploration or production at the present time.

The consequences of the Macondo well disaster for the offshore oil industry

On 22 April 2010, the Deepwater Horizon exploration platform sank following an explosion and fire caused by a BOP (Blow Out Preventer) safety system malfunction.

Oil leaking from the shaft at an estimated 5,000+ barrels per day created an oil slick covering an area of 20,000 km².

The disaster led to a moratorium on deep offshore drilling, a review of licence allocation procedures and the tightening of technical constraints on deep water, high-pressure drilling techniques.

Brazil, Norway and other countries involved in deep offshore production have also reviewed their licence-granting procedures.

The effects of the moratorium continued to be felt in 2011. Drilling resumed in February, although the resumption in activity was decidedly slow. By July, drilling licences were being granted at only half the rate seen in 2009.

Nevertheless, it is expected that activity will recover in 2012, especially following the allocation in December 2011 of new exploration licences for the deep offshore sector of the Gulf of Mexico.

Prospects and future investment

The new reserves of oil and gas to be developed in the deep offshore between 2011 and 2015 are estimated at 28 Gboe.

According to Infield Systems, these developments will require investment of \$210 billion, broken down as follows: pipelines and flow systems (38%), subsea completions (36%) and platforms (20%).

This total is 60% higher than that for the period 2006-2010. To provide an idea of the scale involved, it is instructive to note that 1,300 subsea wells are scheduled between 2011 and 2015. The majority of planned developments are concentrated in the three regions of Africa, Brazil and the Gulf of Mexico.

Africa will be the focus for one-third of investment (\$70 billion) in the period 2011 to 2015, with particular emphasis on developing the major deep offshore pipeline between Algeria and Italy, and development of the floating production system for Total's Egina field in West Africa. Then comes South America with \$50 billion of investment, and North America with a similar figure.

Six operators will provide 75% (\$150 billion) of the investment planned for the period 2011-2015: Petrobras, Total, Chevron, BP, Shell and ExxonMobil (in descending order of size of investment).

In conclusion

Offshore hydrocarbons now represent real potential in terms of reserves and production. The recent French Guiana offshore discovery confirms this fact.

In future years, it will be deep and ultra-deep offshore developments that are likely to provide the majority of growth in offshore oil and gas production.

As water depths increase, so will the level of investment required. More than \$100 billion will be spent in this area of the industry every year. The technological challenges involved demand significant levels of research and development, to which the world's leading oil companies and oil services companies — many of them French — continue to contribute.

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See also: "Investments in Exploration-Production and refining – 2011" on the IFPEN website: www.ifpenouvelles.fr/publications/available-studies