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Innovation
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Norwegian
Energy Partners

Brazil E&P Industry Overview

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Foreword

Introductory remarks from Norwegian Embassy and Consulate

We are pleased to present to Norwegian companies and institutions this comprehensive market review of the Brazilian Oil & Gas sector that IHS Markit developed. The new challenges stemming from the covid-19 pandemic in terms of energy demand and global oil prices have generated global uncertainties. We believe that accurate and up-to-date information about the sector and about the implications of recent market disruptions are vital for any company or institution looking to do business abroad.

Brazil has always been a traditional market for Norwegian oil and gas suppliers and service providers. In fact, Norwegian companies have participated in the development of the Brazilian Continental Shelf from the very beginning, supplying the Campos Basin with technologies and solutions in a rich and two-way exchange of knowledge between Brazil and the North Sea. This partnership not only remains solid but also grows every year, this time with Norwegian companies actively participating in the development of the Brazilian Pre-salt, in joint research and development programs, and in fruitful technical-regulatory exchanges among government agencies.

Norwegian presence in the Brazilian oil and gas sector is solid. Our last Investment Report showed that the 5-year period from 2013 to 2018 was historically strong for Norwegian investments in Brazil. The total investment exceeded US\$ 10.1 billion, with US\$ 4.2 billion added in the 2017 -2018 period. Out of that, 65% of the Norwegian investments in the country were in the Maritime, Offshore and Oil & Gas sectors.

Brazil is facing a strong expansion of its energy sector, with the development of large E&P projects. We are proud to see that Norwegian companies are continuously positioning themselves to take part in it. There are many opportunities out there, but there are also challenges. Nonetheless, we are confident that Norwegian companies are ready to manage them in a responsible way and by sticking to innovative solutions. We believe Norwegian companies can play an important role in addressing the challenges related to sustainability, thereby exploring the technological opportunities to manage GHG emissions, increasing safety and security, as well as providing cutting-edge solutions in digitalization. The covid-19 pandemic has challenged us to support Norwegian businesses abroad in new ways, and we truly hope that the present market analysis will provide your company with the necessary tools to assess market conditions, opportunities and bottlenecks in this market. We are proud to support Norwegian companies in Brazil and we are happy to participate in their endeavors to expand and internationalize their businesses. Brazil has a strong presence of Norwegian government agencies working towards business promotion. Our Team Norway family present in the country is strong and has its doors open to support companies in a wide range of services and sectors.

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Nils Martin Gunneng – Ambassador



Marianne Fosland - Consul General

Brazil E&P Industry Overview

Latin America Costs and Supply Chain Service

E&P Industry Context

The oil and gas environment is extremely dependent on the political bias, especially in Latin American countries. Therefore, the current situation of the Upstream market in Brazil will depend on the central ideas the government has for the energy sector. Either maintain a dominant and central role of the national oil company (NOC), Petrobras, in the hydrocarbon sector and have a centralized government resistant to foreign investments or have a more-open government approach and balance of the NOC role.

In Brazil, there was a high level of government interference between 2002 and 2015. During this period the pre-salt was discovered and some laws and contracts were made and gave Petrobras the responsibility for the development of oil and gas industry under an increased local content target. A large expansion capacity took place in the country in different segments including shipbuilding, subsea, drilling market. The move paid off; however, the downside was cost escalations and some delays of the projects. The problem was aggravated when the oil price fell in 2014, which impacted Petrobras' financial health at the same time, a major corruption scandal emerged involving Petrobras directors, national and international suppliers. The consequences were bankruptcies, legal actions against large suppliers, and paralysis within Petrobras over major restructuring. The local content requirements for offshore construction remained, forcing the use of Brazilian contractors that could neither be hired nor depended upon to maintain ongoing construction projects. Therefore, the work schedules for already-delayed ongoing projects were extended even further.

In 2016, a new government took office and, despite (or perhaps because of) its relatively tenuous position, quickly implemented several measures to improve the regulation of energy policy and Petrobras's management guidance. The situation began to change with the end of Petrobras's state-mandated operations in the pre-salt oil fields. Then the divestment plan was advanced, the local content targets were reduced and simplified, and an agenda of new rounds was announced—two to three rounds per year in the short term. Today, there is reasonable independence from the government and a solid framework to attract foreign investments. The main characteristics of these changes were:

- **Bid round agenda:** A periodic offer of good areas, including the opportunity to foreign companies to be operators in pre-salt areas, not just in partnership with Petrobras. Aggressive competition for exploration blocks abutting the so-called pre-salt polygon in Brazil's Round 16 in October 2019 yielded approximately USD2.1 billion in signature bonuses, a new record for a bid round held under the concession contract regime. One-third of the 36 blocks on offer in Round 16 were awarded. The success of Round 16 was largely due to strong participation by international oil companies (IOCs) with an established presence in Brazil. In August 2020, the National Council of Energy Policy (CNPE) approved a resolution authorizing the National Petroleum Agency (ANP) to carry out the 17th and 18th tax/royalty bid rounds in 2021 and 2022, respectively. In

addition, the government has plans to have the bid round of Transfer of Rights Surplus of Sepia and Atapu field in 2021.

- **Prioritizing pre-salt development:** The Bolsonaro administration has prioritized attracting foreign investment in Brazil's pre-salt. In November 2019, Brazil held two pre-salt auctions – the Transfer of Rights (ToR) surplus volumes bid round and the 6th pre-salt bid round. However, the absence of bids from majors and large independents in both bid rounds reflects a cautious approach to capital spending by IOCs – a trend that will likely persist in the aftermath of the COVID-19 pandemic. Investor concerns about a long-term decline in oil demand and an increasing wariness about financing fossil fuel projects due to environmental, social, and corporate governance (ESG) pressures have likely made investment in large deepwater projects less attractive, particularly under Brazil's pre-salt PSC terms. These challenges are expected to force Brazil to improve E&P fiscal and contractual terms for pre-salt acreage before auctioning additional assets.
- **Petrobras divestments:** There is an increasingly recognition of the limits of Petrobras's financial and operational capacity and the need to move away from the government's historical over-reliance on the NOC to fund upstream investments. The NOC has a substantial upstream asset divestment plan, which comprises 254 fields located in onshore and shallow waters. Petrobras had concluded the process of divesting 60 fields through first half of 2020. Petrobras attracted several investments from foreign companies that feel a more solid ground and less uncertainty in the regulation of the sector to operate in the country. The administration also continues to push substantial divestments of the NOC's refining, transportation, and natural gas assets.
- **Gas regulation:** In 2020, Brazil moved to open its natural gas market to private competition, breaking the monopoly held by Petrobras. The change in the gas market is underway, which is considered very important to facilitate the participation of foreign companies as operators in the country. Today, the offshore pipelines, most of the onshore pipelines and the gas processing facilities that receive the offshore lines belong entirely to Petrobras. Private operators must build their own infrastructure to reach the market. Some divestments such as the sharing of the pipelines and gas processing facilities of Petrobras are ongoing, and it will favor the opening of the natural gas market.
- **Local content:** Successive leftist governments led by the Workers' Party (PT) used the energy sector to implement broader economic and social policy goals. This included the application of stringent local content rules as a means to leverage oil-sector investment to revive the flagging shipbuilding industry and create jobs. In contrast, Bolsonaro, like his predecessor Michael Temer, favors the gradual reduction of local content requirements. Therefore, a review of the local content framework was implemented, that went from a very descriptive list of items with a target of local content, to an average approach by system (exploration, production unit, drilling and subsea). The local content levels reflect the current capacity installed in the country and reduce the possibility of high local content fines/penalties.

- **Less emphasis on integrating energy policy with development objectives:** Besides the local content rules, PT governments also pressured Petrobras to maintain a fuel pricing policy that kept domestic prices below international prices in order to limit inflationary pressures. Bolsonaro's programme also supports Petrobras setting its fuel prices at market rates. However, Bolsonaro's backing for an 11-day truckers' strike against fuel price hikes in May 2018, which was widely supported by the Brazilian public, demonstrates the potential for state intervention when faced with strong social pressure.

The outlook of demand for Brazil was really good and increasing by the end of 2019 due to a large number of good signs, such as the bid rounds with several majors acquiring large areas, the solution of the transfer of rights surplus that allowed renewed investments in the area and the maintenance of the administrative independence of Petrobras guaranteed by the new government which took place in the beginning of 2019.

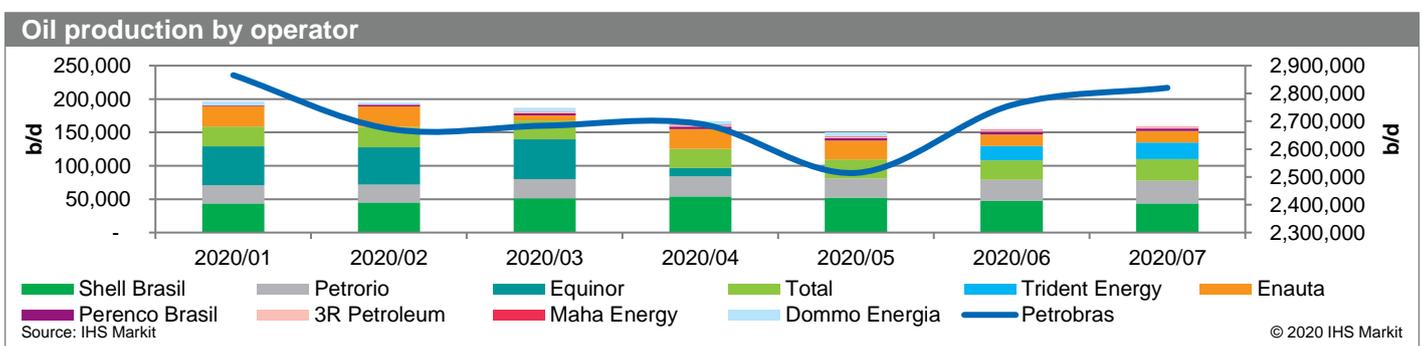
In the same period, pre-salt has overtaken post-salt as the main production region, the exports of oil skyrocketed, in large part because of the much bigger share of the IOCs partners of Petrobras, whom usually sell at the international market their share of oil.

In 2020, due to the COVID-19 pandemic, Petrobras increased significantly its oil exports to China as a way to offset the drop in the domestic demand. As a reference, Brazil exports to China went from 240,000 bbl/d in late 2017 to up to 1.4 million bbl/d by mid-2020 in the peak of the domestic market recession.

Following this trend, we expect to see the same level of participation of IOCs over the next few years, but with a gradual increase as the exploratory programs advance. Furthermore, while the production is exceeding the internal consumption, higher level of exports is expected to be the new normal. Adding on top of this trend a stable regulatory environment and soon the resumption of the bid rounds in 2021, new players will be attracted to foster investments in the market.

Brazilian production by operator

The participation of the IOCs as operator is still timid, achieving not even 10% of the country's total oil production. In 2020, this participation remained basically stable, the main difference however, was the stoppage of the production of the Peregrino field, operated by Equinor. This was due to a preventive maintenance stop to perform safety inspections after facing operational problems and which was further affected by the pandemic.



The fiscal production of other companies, mainly Shell and Petrogal are much higher, because they are partners of Petrobras in several pre-salt projects, with participations around 25% and 10% respectively. However, in this case, the partners have little decision-making power over Petrobras's procurement choices or the selection of technologies.

In the near future, as soon as Bacalhau starts to produce, Equinor will be the largest international operator in the country. ExxonMobil has 40% share in Bacalhau field and in the short term, may have also a sizeable participation in the Upstream market. The company increased its presence in the last bid rounds, in which acquired areas as partner with Petrobras in some pre-salt fields and as operator in other promising areas.

Therefore, Shell, Equinor and ExxonMobil are expected to become the main private players in Brazil, after Petrobras, for the next 10 years in investment and procurement. Total have a relatively good participation nowadays but will probably be overtaken by the others.

Other operators such as Petrório, Trident Energy, Perenco, 3R Petroleum and Maha Energy have increased participation since the last year with the Petrobras' divestments. Petrório has recently acquired Tubarao Martelo field from Dommo Energia, former OGX, as well Polvo and Frade field. The company plans to unify these fields and operate them as a cluster to reduce cost and redundancy. Enauta is producing at Atlanta, a small field and had plans to proceed with the full commercial development. However, following the recent decision of the partner Barra Energia to abandon the project, the project is being reevaluated to become more robust and resilient to the low oil price scenario.

Drilling Market Overview

The drilling market is the one with the largest impact in the capital expenditure of a project. In great part, the reduction of the break-even price for the pre-salt areas from US\$ 65 to US\$ 35 was achieved by cost savings in the well construction. Some key technologies helped increase the productivity, reducing the number of wells to be drilled; others helped to reduce the drilling time, and there are of course the reduction in day rates of drilling rigs, that went from US\$ 450,000 to as low as US\$ 250,000 in some cases.

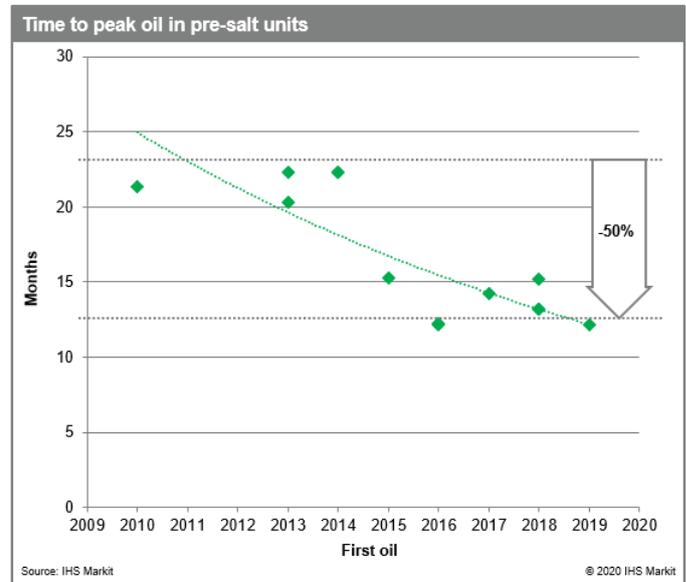
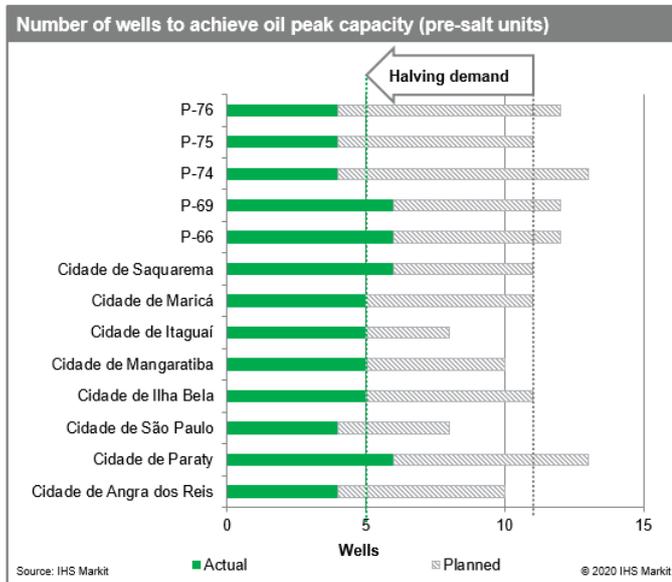
The first factor to explain is the increase in productivity. In the early years of the pre-salt production, the productivity was around 20,000 bbl/d in average as there was a restriction in the production because of the size of the flowlines and risers diameter. Also, there was a need of more injection wells, for each production well, there was one injection well (almost 1:1) and more wells were planned to deal with the high thickness of the reservoir, which was unknown.

The technological improvements helped reduce by half the number of wells originally planned. The success of the injection of CO₂ and water helped maintained the characteristic of the reservoir and permit long plateau of production. Much longer than observed in Campos basin for example, where after one year in peak the water production start to grow fast. Currently, pre-salt wells kept the peak of 35,000 to 50,000 bbl/d for years.

The key technologies to improve productivity and reduce number of wells were the water-alternate-gas (WAG), Christmas trees, subsea systems that allow the alternated injection of water and gas (and with CO₂), the increase in the internal bore of the flowlines and risers from 6" to 8" and the intelligent completion.

The last one with strong effect both in the high peak production and in the long plateau. The carbonate reservoir is also extremely heterogenous and tick, so the use of intelligent completions play an important role in the development because the ability to remotely monitor and control individual intervals, adjusting the pressure and flow of each section to equilibrate the well. In general, every two or three planned wells have been replaced by just one.

The drilling time of each well also was reduced by more than half and is nowadays much more predictable. Not only the average drilling time was reduced but also the standard deviation.



The construction of the pre-salt wells is particularly complicated because the movements of the salt layer and the uneven distribution of loads in the casing across the depth. This is very dramatic in pre-salt where salt flow tends to close the borehole and can cause collapse of the casing. This is even worse if the borehole is irregular what makes more difficult to proper cement fill the annular space. Salt is also hard to drill what requires more load on the bit which may cause angle building problems, making it worse to keep a stable trajectory. So, it is extremely important the technologies related to the measurement while drilling, to increase the rate of penetration without the construction problems that can cause the loss of the well.

The corrosion environment where the wells operate is also challenging, the 13-Cr family is a type of steel relatively cheap already adopted, because despite the high content of CO₂, the chemistry of the reservoir makes the environment less corrosive than expected. Christmas trees are nowadays fully clad with Inconel, which makes their construction longer and more expensive but this already a standard technology.

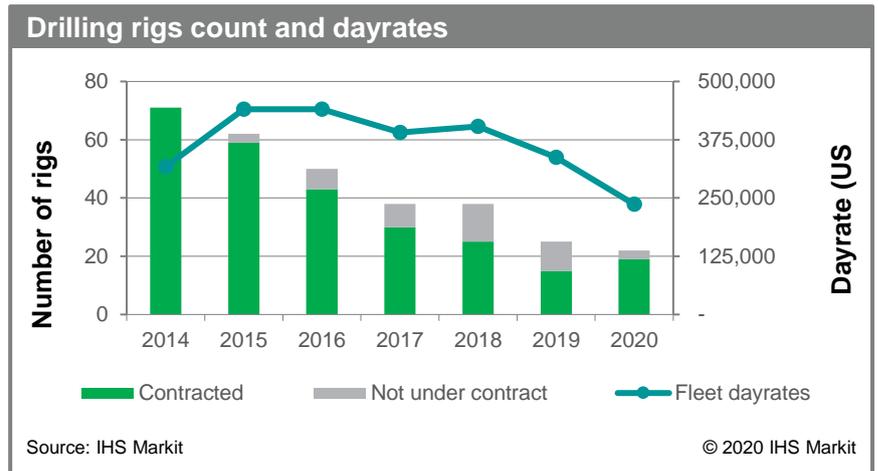
So, materials corrosion issues at the well construction is a relatively solved question, but solutions that can reduce the weight of the systems are always welcome, given the increasing depths of installation.

The most important technology for drilling time reduction, however, is the pressure mudcap drilling (MPD). The pre-salt reservoir is very heterogeneous and have several large cavities that, when hit by the drilling bit, can cause a severe

pressure drop in the mud column and significant loss of drilling fluid to fill the extension of the cavity. MPD reduces this risk and the loss of material. Other more recent technologies are the adoption of fluids with a simpler rheology, which can keep the safety without being so expensive. This is an area of continuous improvement due to the relatively low number of rigs with MPD, and/or the higher dayrates of the few ones that already have (up to US\$ 35,000/day more expensive).

This chart shows the reduction of the average day rate of the operating fleet, which dropped more than 50% since 2014, following the reduction of the rig count in the country.

The rig count didn't fall with the average dayrate immediately after the 2014 downturn because the practice in the country, to hire with long contracts (4 years with extensions to 8 years). So, at the downturn these vessels could not be put out of service, without paying large fines for premature contractual ending.

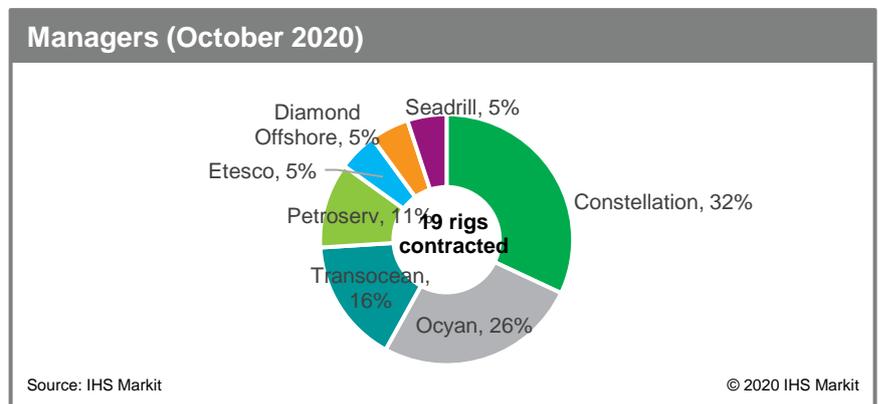


But with the continuous end of the contracts, Petrobras reduced the activity of drilling to reduce its capex and to match the speed of construction of the FPSOs, that were much longer than expected at 2014.

This continuous pressure over the demand allowed the company to continuously renew contracts, in smaller number, and with lower day rate. The equilibrium of demand for new projects under the new oil price and operating vessels was achieved only in 2019, around 20 rigs, just when more IOCs started to hire for exploratory campaigns committed at the bid rounds.

Nowadays, there is the lowest rig count since the pre-salt discovery, but it is stable at this value, with no expectation of falling even more with the persistence of oil price at low values.

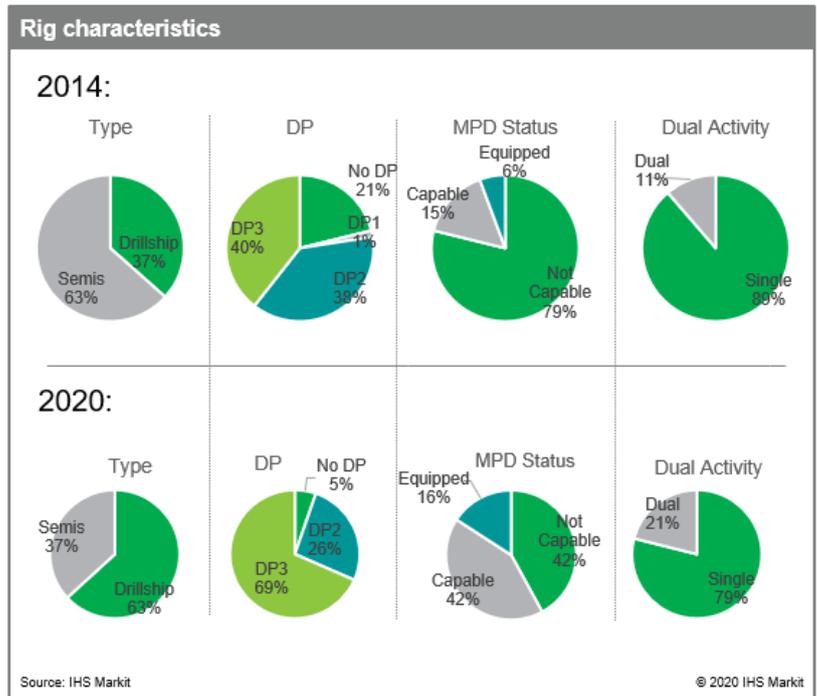
The Brazilian market is shared by two main companies, and others with smaller participation.



Constellation (former Queiroz Galvão) and Ocyan (former Odebrecht) are the biggest Brazilian contractors, and the ones with more aggressive day-rate discounts, also due to the dependence of the domestic market for their fleet. These companies faced very troubled years and financial problems in the last years and are still recovering, but they are being successful in keeping their fleet in operation.

In terms of technology and market, most of the vessels are drillships, DP3, with increasing adoption of MPD, but still single activity. Petrobras is adopting alternate activities for the vessels in each of the main projects, being one for drilling and other just for completion. This is more the practice adopted in production sharing agreement (PSA)¹ fields. In the concession fields the drilling is managed better from a fleet of vessels while in the PSA there are dedicated vessels for each project.

The rig demand for the next years, we will see a recovery in the growth trend just after 2023. The Brazilian drilling market will demand high-technology rigs, and the trend is to have shorter contract durations to guarantee the current low day rates. IHS Markit estimates that the rig demand will require only 20 rigs per year on average during 2020–25: the number of the current fleet. However, it is expected an increase in number of operators drilling in different basins as a result of the recent bid rounds. Owing to the impacts of the COVID-19 and oil crash, a reduction of 25% of the wells demand is projected with a total annual average of 60 wells.



Subsea Market Overview

¹ **NOTE:** in the PSA contracts there is the figure of the “cost oil”. It means that the cost of the oil is reimbursed by the government. All the expenses are presented to PPSA (Pre-salt Petróleo SA), the government company that takes care of all the bureaucracy, that computes all the fair expenses in the area. Of course, the simpler way to show the expenses without trouble is the use of a dedicated and exclusive infrastructure to each contract (or each block).

The subsea market can be divided in three great phases.

Phase 1: The first phase with an still unknown pre-salt, where the approach adopted was basically the same as in the Campos basin, but for the pre-salt with the adjustments for a higher pressure rate, and very sophisticated materials to deal with the corrosive environment due to the sour gas presence. The proposal was to anticipate the production and assist in the development

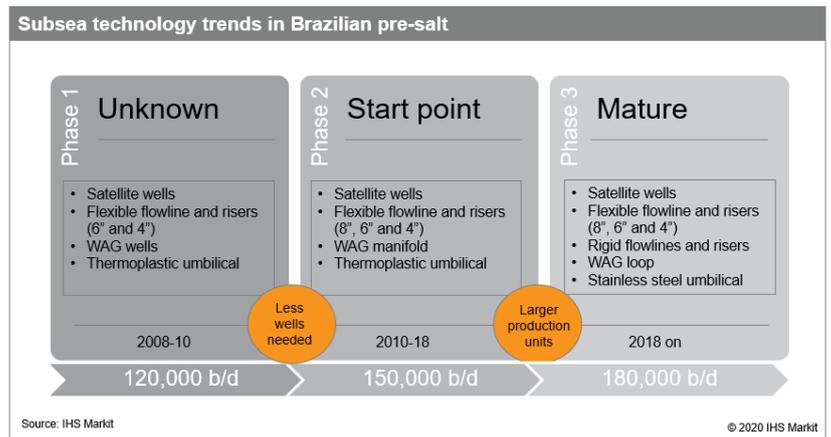
studies of production technology for pre-salt in the Santos Basin. Therefore, a FPSO of 100-120,000 b/d of oil capacity was planned with 20 total wells including producing and injection wells. All wells were satellite with some WAG wells and with the technology at that time (which was flexible flowlines and risers and thermoplastic umbilicals).

Phase 2: In the second phase, the market moved to a little bit different approach with gains in well productivity, with larger subsea lines and risers and the adoption of the WAG manifold. As a result, the number of lines linked to the FPSO has been reduced. Some material requirements were downgraded after research on materials technology has shown cheaper options to deal with the CO₂ in the equipment and lines.

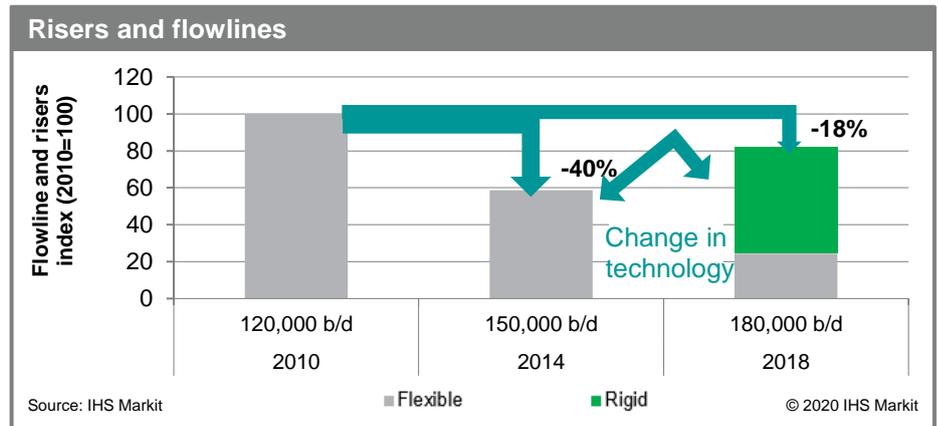
However, these fields have high CO₂ content which had corrosion cracking and caused failures in some gas injection risers. The limited resistance of the flexible riser materials may be a technological barrier, so Petrobras has prompted switch its contracting strategy to rigid riser-based lines for forthcoming developments in the region.

Phase 3: In the third phase, the standard for the current projects on design phase adopt the previous scheme but with a wag single line (or loop) and moving to the adoption of rigid steel flowlines and the stainless-steel umbilical. A trend for the next projects already observed is the adoption of, larger FPSOs. That can become even larger for some of the new projects. Also, new technologies to solve the corrosion cracking is in the agenda and different solutions are under studies. There is a possibility for the usage of a new generation of flexible risers for other developments in the future, as well as gas processing technologies for subsea applications. Operators are looking for cost reduction in most of the systems. For example, the usage of flexible lines in catenary to reduce the installation costs of the lazy wave by 50% due to the elimination of the buoyance devices.

The chart shows the impact of the technological changes by the three phases on the demand of a typical project. It is the total demand of flowline and risers to develop a pre-salt project. The reduction in demand and the change in



technology have an important relevance for the Brazilian market since the subsea segment is well consolidated in the country and most of the capacity expansions took place when pre-salt development started. The expansion was considering the technology and the perceptive demand at that time.



Investments were made just a few years before the 2014 downturn, therefore the demand that they prepared for never became a reality. After a decade of pre-salt production, a platform able to produce about 80% more oil will demand only 25% of the flexible risers and flowlines that the first pre-salt platform demanded. On the other hand, new demand for rigid lines was created. This result also had an impact on the subsea installation segment. New vessels able to install heavy rigid lines will be required to in the short term for some projects.

Suppliers are currently dealing with low utilization rates, low margins and few orders, and pressure on cost reduction and technology change. This is the scenario as suppliers enter this new crisis. It can be challenging to keep reducing capex in this market. Operational cost may be the target, especially with cost savings thanks to digitalization and operational improvements.

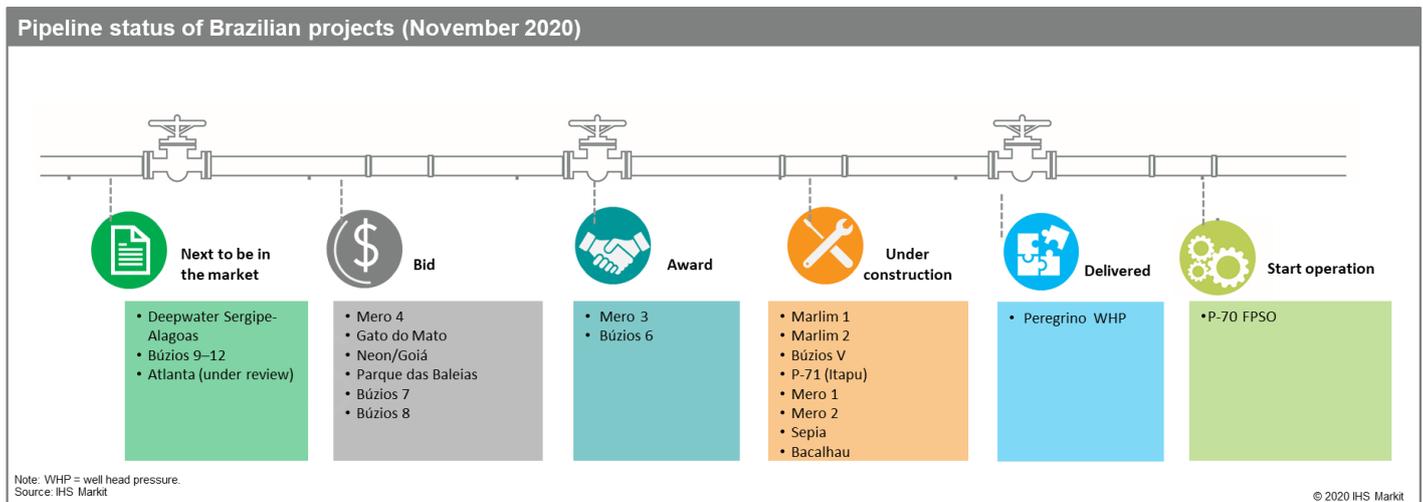
Nowadays, the greatest demand for subsea systems are:

- Larger diameter for production lines.
- Corrosion resistant risers, more sensitive to CO₂ damage due to dynamic loading and fatigue-induced corrosion.
- The injection of H₂S scavenger at the production wells is planned as a contingency to prevent corrosion of the armors by H₂S. But in the flexible, the permeation of CO₂ through the polymeric layer of the risers and the armor corrosion are still a serious problem not yet solved. This is the main driver of the move to rigid lines, despite higher installation costs and fewer PSLVs available.
- For static flowlines, the flexible, rigid line pipes or SuperDuplex piping are considered suitable options.
- For the subsea equipment, the adoption of all electric actuators and controls is still being evaluated. This may be a more suitable technology for very deep areas given the savings in the umbilical demand and to reduce the weight of subsea equipment to facilitate installation.

Brazilian FPSO Market

The pipeline of projects shows the strength that Brazilian projects have in the coming year. As projects are mainly in deepwater, there are at least eight projects under different construction stages, and we do not expect cancellation or big delays of these projects. Most of these projects are large sized pre-salt FPSOs, which means these projects have an excellent economics that can be considered a firm and safe demand.

In addition, despite the pandemic and oil price crash, Petrobras opted to keep tenders in the market, especially for their main priority fields – Mero and Búzios. In order to reduce the CAPEX to deal with the oil price fall, Petrobras slowed down the exploratory drilling and interventions, stopped production fixed units and started a large divestment plan in the onshore and shallow waters.



Other projects like Gato do Mato from Shell, Neon from Karoon and Atlanta from Enauta are smaller and more sensitive to the oil price. They are in early stages and are likely to be postponed.

The FPSO market has a solid demand in the next years with a total of 35 FPSOs in midterm, 40% of this demand is for projects not yet in the pipeline presented above and 70% of this estimated is not yet in procurement phase.

Although the demand is solid, it is much lower than in the years of 2010 to 2014. At that period, at least 15 units between drilling and production units were built at the same time. The current demand is not enough to sustain all the Brazilian shipyards that still exists. In fact, due to the reduction of local content, and because most of the projects are for leased units, the design and construction are likely to be made overseas.

The leased units, in the past, had a procurement strategy of most of the work done overseas and parts of the modules and integration in Brazil. The conversion (or hull construction) made in Asia, together with the construction and integration of some modules (e-house; power generation; flare system and marine systems). The process plant construction was divided between Brazil and some international yards, but the integration was usually made entirely in Brazil, for the leasing and the owned vessels. The main leasing companies, even the ones that also build the unit in Brazil, made all the procurement of the long lead items and equipment outside Brazil, with the specs being released from engineering centers in Asia or Houston. The procurement made in Brazilian yards was mainly for materials, instrumentation, and construction services.

However, several of these units are likely to be owned by Petrobras or other companies. For Petrobras, it is expected the company's engineering team will run a prescriptive tender for the construction with the design based in their internal FEED and embracing new technologies that the company would like to try on its own. The new owned units will be built under EPCI contract, but even for these cases, in the past Petrobras used to select for itself the suppliers of the main equipment and systems, leaving only the construction and integration for the EPC contractor. It is not yet clear whether the company will pursue the same model or contract under a complete turnkey.

In the previous decade, Petrobras moved from owned units to leased units due to the failure of the national EPC contractors and engineering companies in the construction of the large FPSOs for pre-salt. Following the local content targets of the country, Petrobras FPSO's P-66 to P-71 and P-74 to P-77 were initially planned to be entirely built in Brazil, however later on, anticipating huge delays, there was a change of plans and they were transferred to Chinese contractors to either be completed or be entirely built there. The P-71, as an example, is still under construction and was contracted in 2011.

The Brazilian yards were one of the most impacted markets since the 2014 downturn. There was bankruptcy of some yards and loss of productivity and suppliers. As a result, the new wave of orders for the pre-salt FPSOs is being made with few fabrication modules at local yards. Not even integration is being made in Brazil anymore. It is likely that the amount of the construction work in the Brazilian yards will increase to achieve the current levels of local content commitments.

The main remaining yards operating in Brazil and their backlogs are as follows:

- **Brasfels** (or Keppel Fells Brasil), which is the oldest, most experienced, reliable, and with the best track record of success. The yard delivered the modules and will no longer complete the fabrication and integration of all modules of FPSO Carioca in the Sepia field. Modules of FPSO Almirante Barroso is currently under construction at the yard.
- **Jurong Aracruz**, which belongs to SembCorp, is currently integrating the FPSO P-71. Jurong have already a good track record but not even close to the Brasfels. The yard also integrated the FPSO P-68, which is already delivered and producing.
- **Techint**, who had the construction of topsides modules and integration of one of the Buzios FPSO together with the Technip engineering. Some remaining conversion services were done, but they are not experts in conversion and don't have a dry dock for complex hull works. There is no backlog.
- **EBR** (Estaleiros do Brasil), which is a relatively small construction yard – almost the same the size of Techint –but already with some good results. It is also a yard for modules construction and integration with reduced capability for carrying out conversion works.
- **EAS** (Estaleiro Atlantico Sul) suspended and never really worked in offshore projects. It survived for some time from Petrobras orders of oil carriers and some production units. However, only rented the space and infrastructure. All the engineering and labor came from QUIP, in which it is not in operation anymore. The

yard is in bankruptcy since January 2020 and have plans to diversify its activity focusing on repair and maintenance, decommissioning, and the wind market.

Status of selected major fabrication locations

Country	Yard	Backlog	Historical backlog (recent)	Status	Overview
Brazil	•Jurong	Integration of P-71 2 drillship	• Integration of P-68	• The integration of P-71 started in March 2020 at the Jurong shipyard after some setbacks (two compression modules sunk when transporting). Finally, in October, Petrobras decided that this unit will be installed in Itapu field.	<ul style="list-style-type: none"> • This sector has been hit hard since 2014 with bankruptcy of some yards and loss of productivity and suppliers. As a result, the new wave of orders for the presalt FPSOs is being made with few fabrication modules at local yards. There are projects like FPSO Marlim 1 and 2, which will all be fabricated overseas. The Mero 3 FPSO is at risk of being entirely built abroad as negotiations to lower the day rate put some pressure to reduce local content. • For the next Búzios projects, Petrobras will have owned FPSOs under the engineering, procurement, and construction (EPC) model. Petrobras has recently qualified 10 EPC companies to participate in the next bidding process; two of which are local (Brasfels and EBR) and the others are Daewoo Shipbuilding, Hyundai, and Samsung (South Korea); Keppel (Singapore), SBM (Netherlands); Technip (London); and Modec and Toyo (Japan). • Shipyards able to build hulls may not survive, leaving room only for the ones with capacity to construct modules and integration work, which are Jurong, Keppel BrasFELS, EBR, and Techint. • At the end of 2018, SBM decided to shut down the Brasa shipyard for an undetermined period. Although this yard had in the past delivered FPSOs with productivity, few orders are being placed in local yards, and also local content requirements have also changed. Therefore, IHS Markit believes this yard will not return to construction and integration activities.
	•BrasFELS	Modules for FPSO Almirante Barroso (Búzios V) 2 drillship (Urca and Frade)	• Modules for FPSO Carioca P-69 • Cidade de Campos dos Goytacazes	• BrasFELS delivered the modules and will no longer complete the fabrication and integration of all modules of FPSO Carion in the Sepia field.	
	•Estaleiros do Brasil (EBR)	Modules for FPSO Carioca (Sepia) and 4 modules for FPSO Almirante Barroso (Búzios V)	• 2 modules for FPSO Guanabara (Mero 1) • Modules and integration of P-74	• EBR delivered on schedule two process modules for the water treatment system for the FPSO Guanabara.	
	•Techint	-	• Integration of P-76	• Techint finished the integration of P-76 and now has no backlog.	
	•Estaleiro Atlântico Sul (EAS)	-	• Suezmax and Aframax P-55 hull • Module and integration of P-62	• The yard suspended operations since August 2019 owing to financial problems and has been in bankruptcy since January 2020. Currently, there are plans to diversify its activity focusing on repair and maintenance, decommissioning, and the wind market.	

Note: More information is available in the [Cost and Technology](#) section on Connect.
Source: IHS Markit

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Challenges and solutions:

Most of the technological change in the FPSO market is related to gas production. The gas handling represents the main weight of pre-salt FPSO modules. A typical pre-salt FPSO handles 5 to 10 million cubic meter/day, with 20 to 45% of CO₂ in molar basis. The export and gas injection system for natural gas is already large, which includes one 10 MW and vapor recovery unit (VRU) with an alternative compressor, and three trains of three stages centrifugal compressors with electric drivers. In addition to the natural gas system, there is the CO₂ injection system with a separated compressor, four stages centrifugal and gas turbine driven. Most of the CO₂ system is made of duplex cladding material, being the single more expensive module of the FPSO.

Therefore, there is an intensive pressure for cost savings and technological changes in the development of pre-salt fields. For example, the increase of the first separator pressure from 15 bar to 50 bar, the increase in inlet pressure of the separator can avoid the expensive 10 MW alternative compressor of the VRU, and/or the membrane.

The membrane system has some problems:

- Around 8-15% of methane carryover in the CO₂ rich steam (molar).
- A very low pressure of the CO₂ rich steam, that leaves the membrane at 1.5 bar and must be compressed until up to 500 bar, which demands a very large compression system.
- A regeneration cycle that sometimes causes production downtimes.
- Not able to leave the methane rich steam with CO₂ low enough for pipeline usage. It is adopted to bulk CO₂ reduction from 15% to 45% down to 2%, which also causes the need for lining of the gas export pipelines and

an amine systems in land to reduce the CO₂ to 0.5% (required gas specification for city gate deliveries in Brazil).

Some solutions under study are:

- **Relaxation of water content in reinjected gas:** Potential topside plant weight reduction by 1,500t and footprint by 210m². Potential benefits planned: ~5.2% reduction in the dayrate and 0-4 months reduction in the lead time.
- **Increase separation pressure** (Eliminate Main A. Increase VRU (Vapor Recover Unit): Potential benefits planned: ~5.8% reduction in the dayrate and 0-4 months reduction in the lead time.
- **Gas processing technologies:**
 - **Carbon Molecular Sieve (CMC) Membranes:** more efficient membranes for CO₂ separation from natural gas. [Under studies with Shell]
 - **All Membrane Technology:** compact gas treatment system capable to remove H₂S, CO₂ and water; Reduction in topsides weight and FPSO cost or possible enabler to increased plant capacity. [Studies with Air Liquide]

The subsea separation of CO₂ is an experimental project that would allow a large enough reduction of the topsides footprint to accommodate a sweetening gas system, allow the export of gas at pipeline quality and would also reduce all the CO₂ injection compression system. So, in terms of topsides technology, everything related to the gas, CO₂ and compression is a major concern for cost, weight and space savings at the FPSO, not to mention all the ESG pressures for lower emissions.

All this hardware for the new large FPSOs are in the limit of adoption of VLCC hulls. The best design for the current size is wider, with a deck space larger to accommodate wider but shorter modules. These modules, with two deck levels instead of three, are more stiff, easy to build and facilitates the integration, saving a lot of manpower and steel. Modec and SBM have a design for a new generation of the newbuild hull for units greater than 180,000 bbl/d– M350 double-hull floater and Fast4Ward Multi-Purpose Floater (MPF), respectively. These designs help increase the topsides deck area in about 20% than standard VLCC and increase about 30% of topsides footprint to accommodate up to 50,000 ton of operating topsides.

FPSO Market Overview – Global and Brazilian

Petrodata FPSBase service

Global FPSO market overview

The FPSO solution is the most popular of all FPS units at present as it represents almost half of the total FPS fleet. It is anticipated to remain that way for the foreseeable future as FPSOs account for approximately 45% of all other FPS units under construction and about 51% of the total FPS demand.

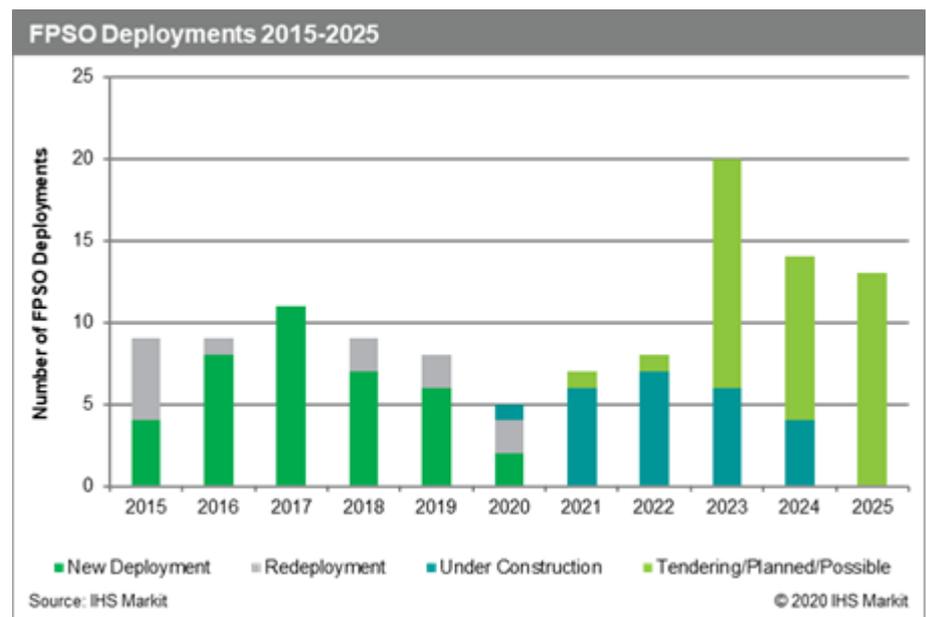
Global contracting scene

The FPSO market is however also subject to changes in the market environment, such as lower oil price levels. For instance, contracting activity for FPSOs was impacted by the downturn that commenced when the oil price started to drop at the end of 2014. Only three FPSO awards were recorded in 2015, in comparison with 10 in 2014. In 2016, no new deployment orders were announced and only one redeployment was announced as Hurricane signed heads of terms with

Bluewater for the redeployment of the FPSO Aoka Mizu at the Lancaster field, offshore the UK.

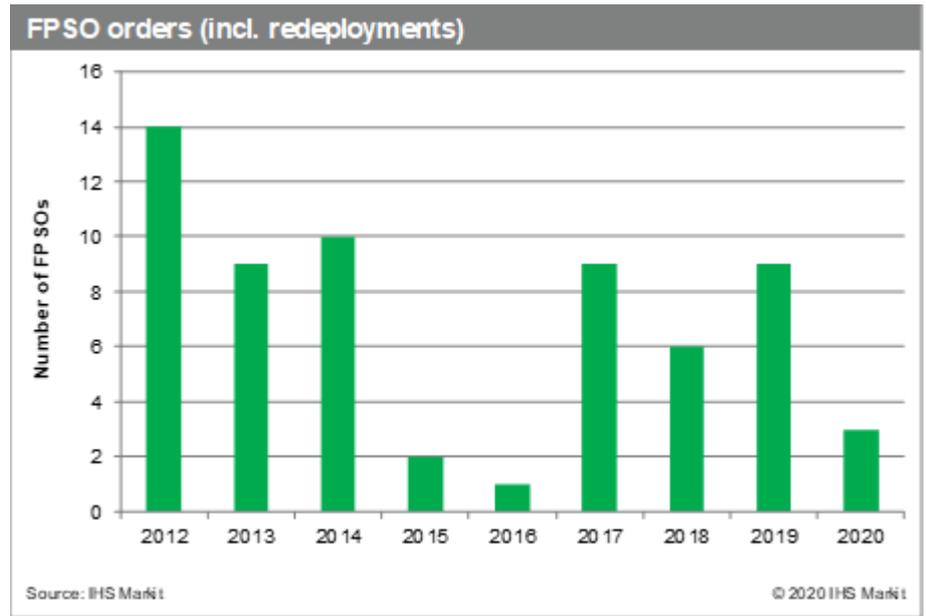
It is from 2017 that the FPSO market started to recover as a total of six new deployment contracts were granted.

Petrobras played an important part of the recovery as the operator started awarding FPSO contracts again from 2017. That year, the operator contracted MODEC to supply the FPSOs for its Sepia as well as for its Mero projects. In total and since 2017, the operator has signed seven contracts for new FPSOs to operate in Brazilian waters. Other regions

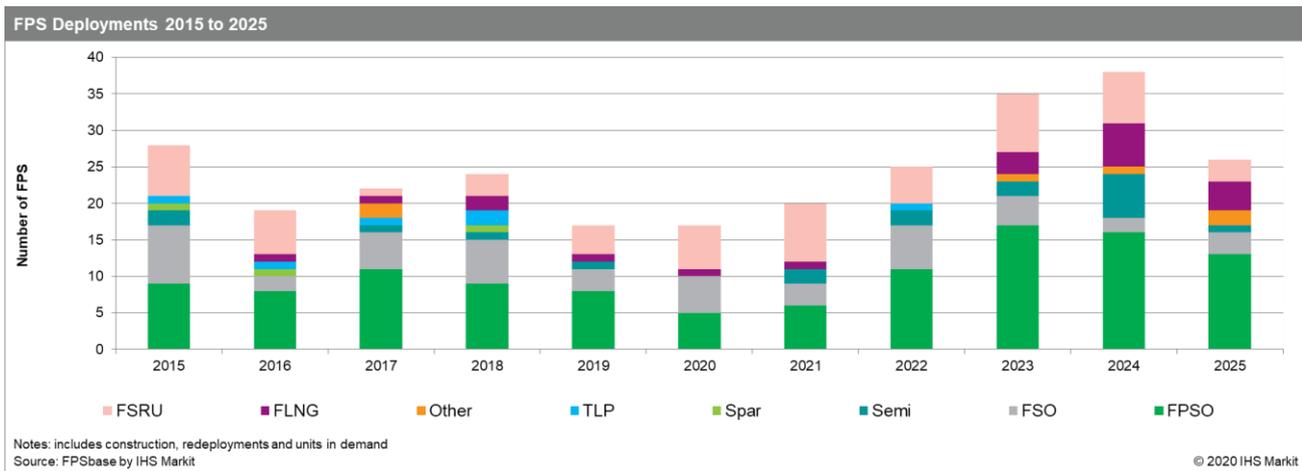


which have contributed to a market recovery were West Africa, Asia Pacific, and Northwest Europe. The three regions have accounted for a total of 16 awards since 2015.

In 2020, COVID-19 has further challenged the FPSO market, making the timing of projects uncertain again. Several projects which were initially meant to be awarded this year have been pushed back to later dates. Two awards were announced earlier this year

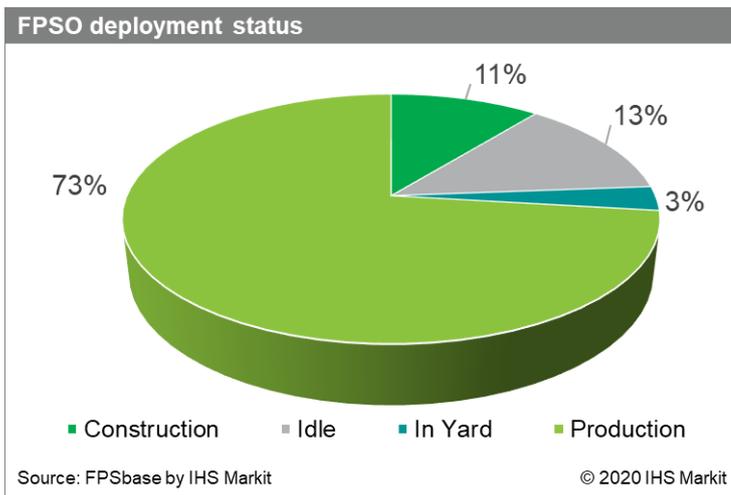
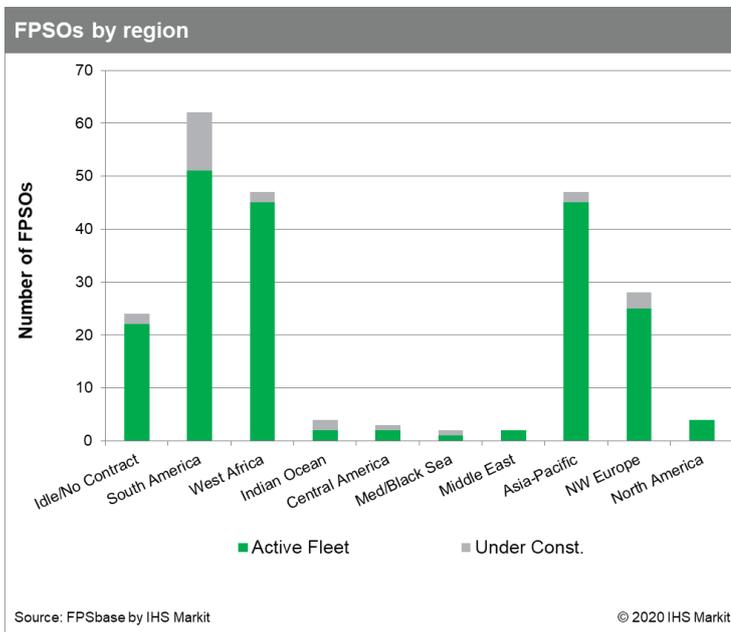


prior to the market being put on hold because of the pandemic. In January, MODEC was awarded an EPC contract for Woodside’s Senegalese Sangomar project as well as a FEED contract with a transition to EPC for Equinor’s Brazilian Bacalhau project. In February, Yinson signed a letter of intent (LOI) with Aker Energy for an FPSO to operate at the Pecan project. However, the contract was shortly after cancelled as the operator decided to postpone the Ghanaian project in light of COVID-19. No new FPSO awards was recorded until August when Petrobras awarded MISC the FPSO lease for the Mero 3 project, offshore Brazil. Then in October, SBM inked the lease contract with ExxonMobil for the Payara project offshore Guyana. The award resulted from an exclusive FEED contract with, in the terms, a transition to a firm award.



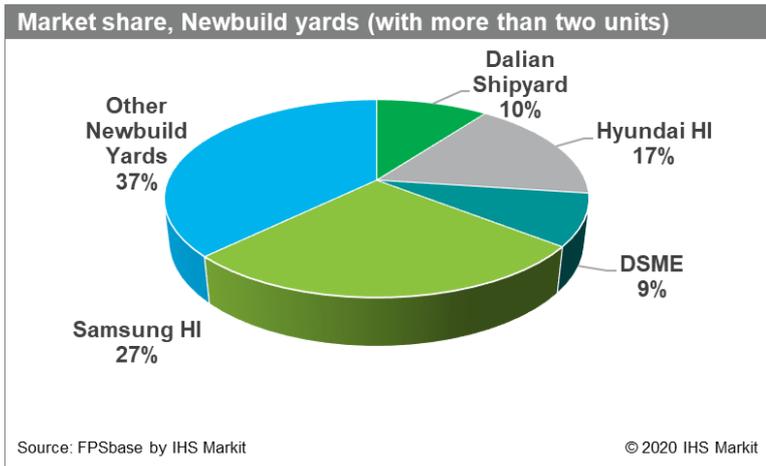
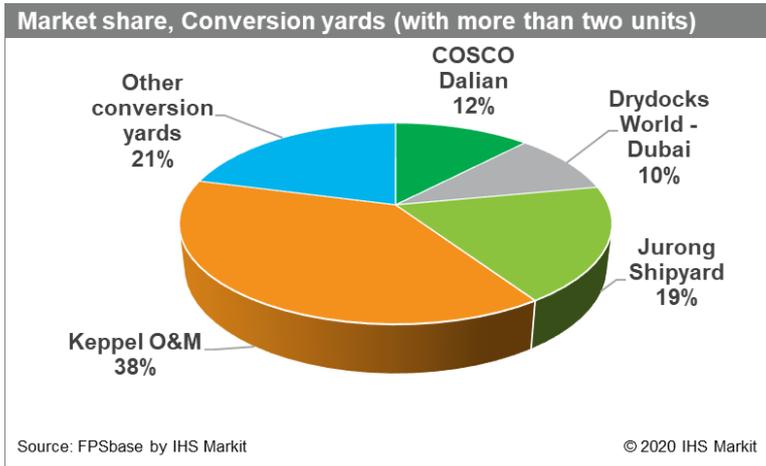
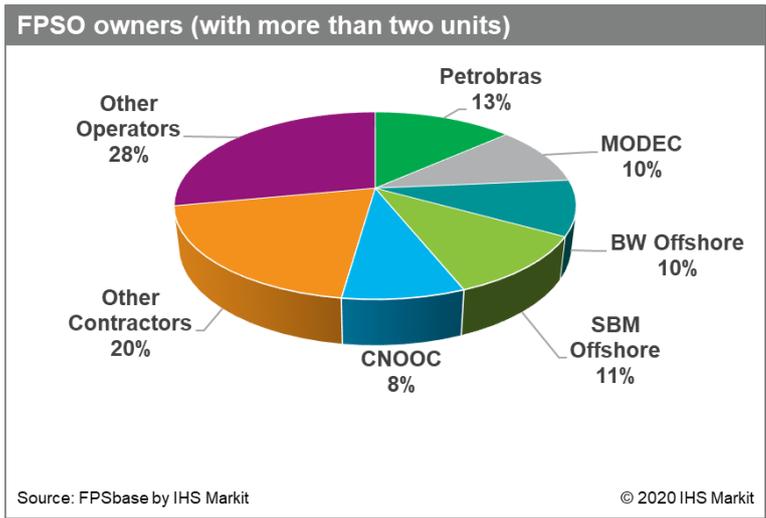
The FPSO market holds the largest share of the total FPS market as it represents almost half of the total FPS fleet. Demand for FPSOs over the years has been constant since the first ever FPSO came onstream in 1977 at Shell’s Castellon field, offshore Spain. FPSOs proves to be a popular solution as those units can be tailored to various types of developments from a relatively small to a larger scale project. Additionally, the required level of investment will be

different in function of the size of the FPSO and whether the operator chooses to opt for a redeployment, or for a converted unit or a newbuild FPSO.



The main region that drives FPSO demand is South America. And in South America, Brazil dominates the market. Brazil is therefore the main market in South America but also the main market in the world as it holds a quarter of the total FPSO fleet in the world

Find below some graphs on Market Share, Owners and Contracts.



- **A new form of contracting:**

A closer collaboration between contractors and operators at an earlier stage of the tendering process was observed during the downturn. This resulted in an increased number of exclusive FEED with a transition into a firm award when a final investment decision (FID) is taken. This new form of contracting was observed in various regions in the world. In West Africa, MODEC and TechnipFMC were contracted under those terms for, respectively, Woodside's Sangomar project and BP's Greater Tortue project. In South America, ExxonMobil used this method of contracting with SBM for the Liza and Payara projects located offshore Guyana. Offshore the UK, Sembcorp Marine is carrying out a FEED with transition to EPIC for Siccar Point's Cambo field. This trend continued in 2020 when MODEC was awarded the exclusive FEED for Equinor's Bacalhau project.

Petrobras had encountered problems with yard delays therefore the operator decided to lease instead of owning to reduce its exposure to risks. However now they are looking at owning FPSOs again to increase competition in the market. By starting owning FPSOs again it means that they have a new pool of contractors to choose from.

- **Standardisation:**

Standardisation has also been a prevalent topic during the downturn in different segments across the oil and gas industry as contractors were aiming to reduce costs by developing solutions which can easily be replicated to other developments. SBM Offshore has so far been the most successful to put this idea into fruition with its Fast4Ward technology which aims to improve the commerciality of deepwater projects by offering a newbuild FPSO with a generic double hull. SBM has already ordered five of the Fast4Wards hull from two Chinese yards, SWS and CMIH, and has firmed up three contracts for; those. Two will be deployed offshore Guyana, at ExxonMobil's Liza Phase 2 and Payara projects, while the remaining one will be deployed at the Mero 2 project offshore Brazil. MODEC has also progressed on the standardisation route with the M350 newbuild which the company jointly developed with China's Dalian Shipbuilding Industry Company. The M350 design will be used for ConocoPhillip's Barossa project, off Australia.

- **Redeployment market:**

The redeployment market was not as badly impacted by the downturn as the new deployment market, as a total of five redeployment awards were announced during the downturn, including one award in 2016. One of the redeployment awards was for BW Offshore's FPSO BW Adolo at the Dussafu block, offshore Gabon. This award resulted from the contractor BW Offshore choosing to diversify during the downturn and to enter the oil and gas market as an operator. BW acquired the Dussafu block and the Kudu block offshore Namibia in 2017. No units have yet been announced for the Kudu development, which is still in the planning. BW has continued with its strategy as in 2019 it acquired the

Maromba field, offshore Brazil, for which the company intends to redeploy an existing unit. The company first planned to redeploy the FPSO Berge Helene but is now considering using the FPSO Polvo instead.

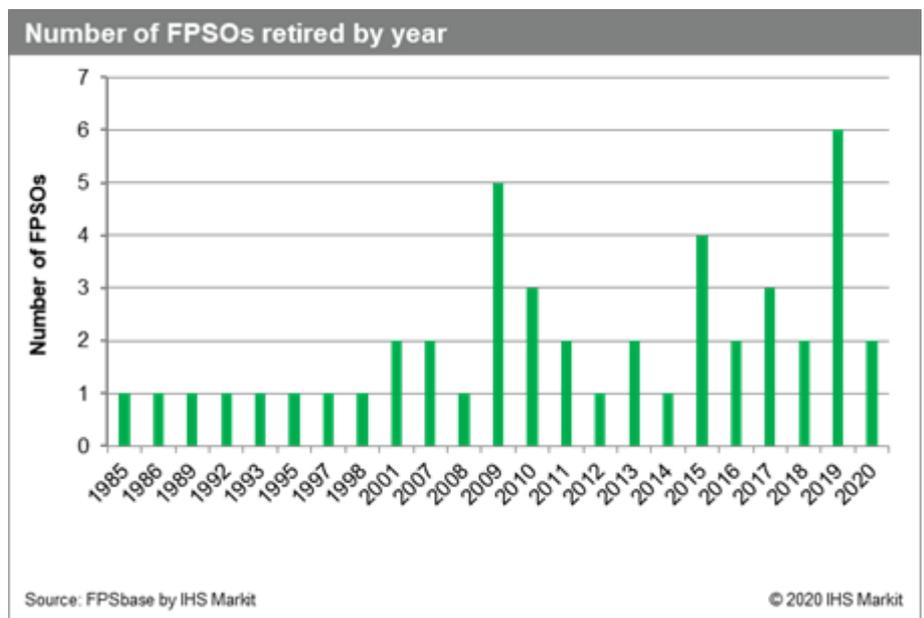
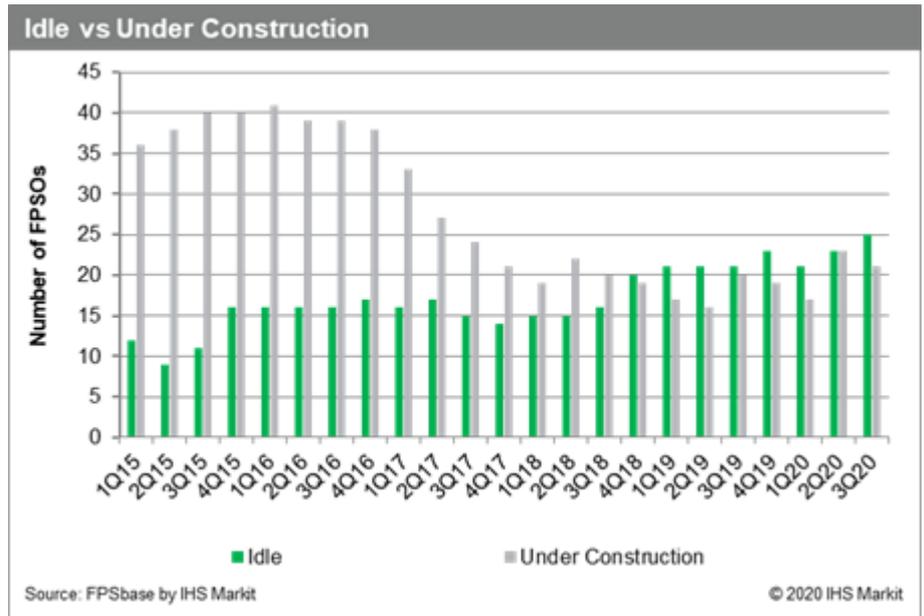
The redeployment market throughout the years has brought a steady but low number of awards. The number of awards in this segment of the market for the last 10 years has fluctuated between none to six a year, with the average

being of two to three a year. Redeploying a unit can be tricky for contractors due to the oversupply of idle FPSOs, especially during the downturn as more units are removed from their fields when commerciality is challenged in a low oil price environment. In addition, FPSOs are in most cases designed for a specific development which can be challenging to redeploy an FPSO to a field it was not specifically designed for.

If contractors cannot secure new contracts for existing FPSOs, it is likely contractors will decide to retire the units instead. A rise of FPSO sold for scrap has been observed during the previous downturn which started in 2015, when compared to previous years. The last time that a high number of FPSOs was scrapped was during a previous downturn in 2009.

The average year of FPSOs being retired is of 16 years, however the age can range from 2 to up to 37 years. Approximately 41% of FPSOs were older than 20 years before being scrapped, while 38% were between 10 and 19 years old, and 20% were 9 years old or less. Also, about 70% of the fleet that is now retired was deployed to only one development.

At present, the majority of idle FPSOs are between 10 and 19 years old. The



high number of idle FPSOs that we are seeing at present was particularly noticeable at the end of 2018, as for the first time, there were more idle units than FPSOs under construction.

FPSO order book

The low number of awards in 2015 and 2016 has had a significant impact on the FPSO backlog. At the start of 2015, the FPSO order book was composed of 35 units and three years later, at the start of 2018, there were only 19 FPSOs left on the order book. This has mostly had an impact on the number of units scheduled to come onstream in 2020 as we anticipate that, at most, three new FPSO deployments will have come online by year-end. The last time only three new FPSOs were delivered was in 2000.

Next year should see an increase in the number of FPSO coming onstream, with six FPSOs in 2021 and nine FPSOs in 2022. However, the timing of deliveries is still at risk of being pushed back if market conditions do not improve.

Contractors in the FPSO market

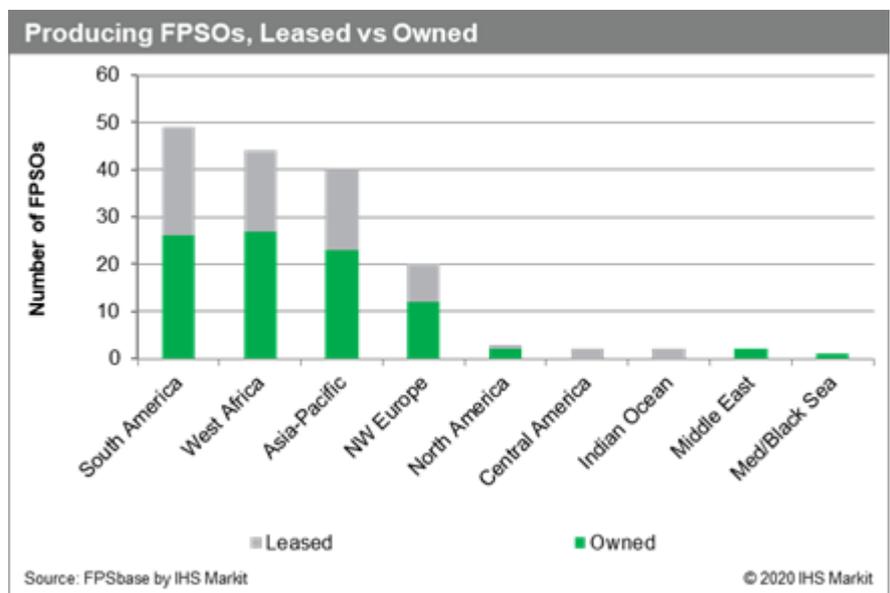
FPSO contracts were granted to various contractors in the industry. However, the most successful contractor was MODEC with eight awards. Of those seven, five were for Brazilian projects. Other contractors which have been among the most successful with contract awards since 2015 include Yinson, TechnipFMC and SBM, with two to three awards each.

- **FPSO leasers and owners:**

At present, about 57% of the FPSO fleet is owned, while the rest is leased.

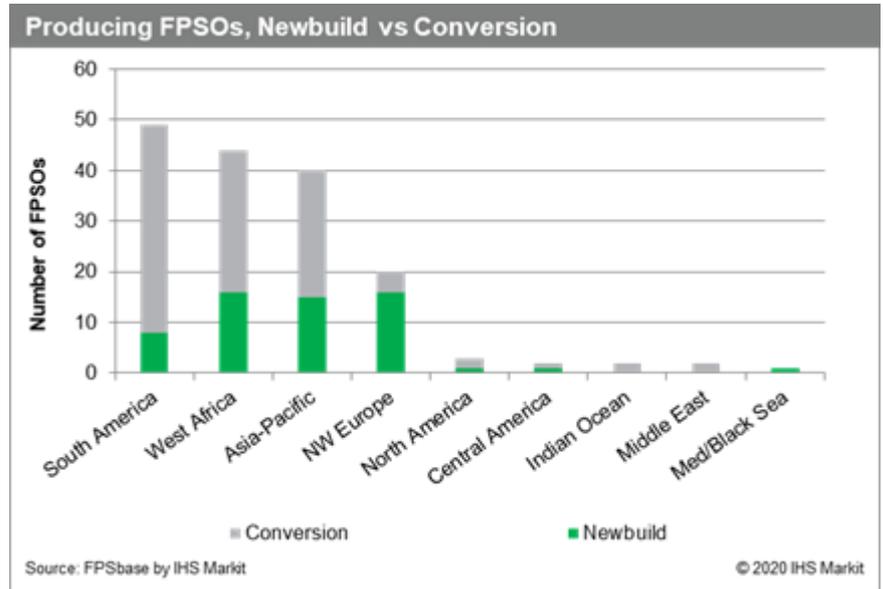
FPSO owners comprise FPSO contractors as well as oil and gas operators that own the FPSO operating at their field. The main FPSO owner is Petrobras with a 13% market share, due to its large fleet operating offshore Brazil. Other owners with large market shares include MODEC, BW Offshore, SBM Offshore, CNOOC with each around a 10% market share each.

- **Fabrication yard:**



Converted FPSOs represent approximately 63% of the total active FPSO fleet. The region with the largest number of newbuild is Northwest Europe, while converted units are more present in South America, in Asia-Pacific and in West Africa.

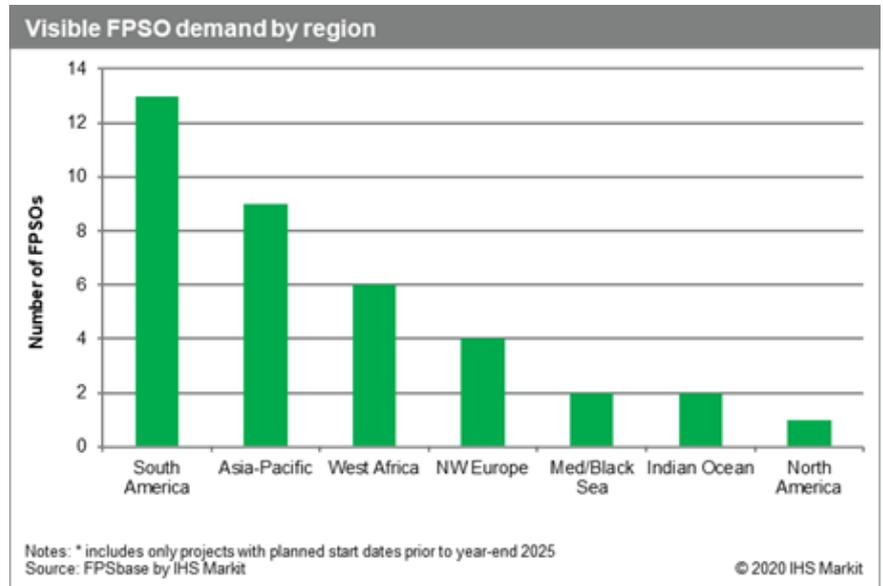
The main yards that can carry out conversion operations are located in Singapore; Keppel holds a 36% share and Jurong Shipyard holds a 19% share. Other yards with a large market share include Cosco Dalian in China with a 12% share and Drydocks world in Dubai with a 10% market share. As for newbuild yards, three of the yards that hold the biggest market share are located in South Korea. This include Samsung HI with a 27 % market share, Hyundai HI with a 17% market share, and DSME with a 9% market share. Dalian Shipyard holds a 10% market share.



Brazilian FPSO market overview

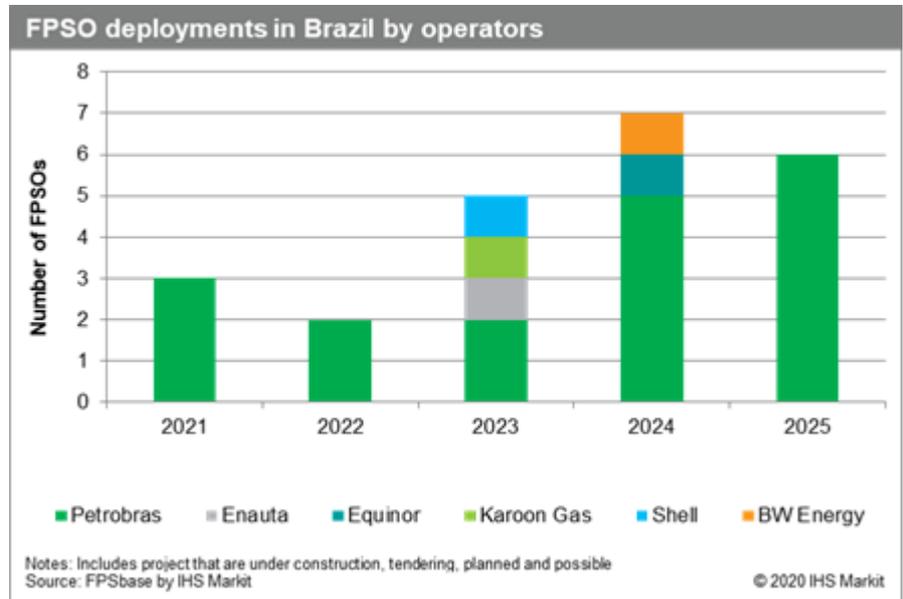
South America is the main market for FPSOs in the world, and within the region, Brazil dominates supply and demand. At present, 49 FPSO are producing in South American waters, amongst which, only one FPSO is producing outside of Brazilian waters. This is SBM Offshore’s FPSO Liza Destiny at ExxonMobil’s Liza field offshore Guyana.

It is expected that South America will remain the main market for FPSOs in the near term but also in the foreseeable future. At present, out of the 24 FPSOs in the order book, 11 are destined to South America which includes nine FPSOs planned to be deployed offshore Brazil. The other two will operate offshore Guyana. As for demand, South America represent 40% of the total visible demand and Brazil represents 86% of the total demand in South America.



Petrobras in the Brazilian FPSO market

Petrobras operates 40 out of the 48 FPSOs which are currently producing in Brazilian waters. The remaining Brazilian projects with FPSOs, not operated by Petrobras, are operated by PetroRio (3), Shell (2), Equinor (1), Enauta (1) and Total (1). Petrobras is expected to remain the main operators in the foreseeable future, as it is expected the operator will generate 79% of the total visible demand. The only other operators that have projects planned to come onstream in the next five years are Enauta, Equinor, Karoon Gas, Shell and BW Energy, with one each.



The operator is moving ahead with an ambitious plan for FPSOs in the country. This results from the operator choosing to focus on its deepwater and pre-salt fields assets. Also, despite the current market conditions, the operator is making progress with its more important and profitable assets. The operator is on track to start production from 12 new FPSOs by 2025, of which, eight are already under construction and four are in the tendering stage.

FPSOs operating in Brazil

- **Lease vs ownership:**

Petrobras is not only the main operator but also the main FPSO owner in the region. The operator owns 36% of the FPSOs currently production in Brazil and out of those, only one is not managed by the operator.

At present 54% of the fleet operating in Brazil is leased, with the rest being owned. The country has recently become an attractive market for FPSO leasers as Petrobras has only awarded lease contracts since 2017. Traditionally, MODEC and SBM are Petrobras' favourite choice and this trend has continued. MODEC was awarded four contracts by Petrobras since 2017 while SBM has been awarded one contract. None the less, Yinson was awarded its first contract ever in the country for the Marlim Revitalization 2 project and MISC also entered the country with an FPSO lease

award for the Mero 3 project. The large number of FPSO contracts that Petrobras aim to award in the near future could open the door to other contractors in the Brazilian market.

However, Petrobras is in the process of rebalancing its portfolio in order to increase competitiveness. The operator is now looking at owning FPSOs again, with first, two FPSOs planned to be deployed at the Buzios 7 and Buzios 8 projects. Also, the company is now pre-qualifying companies that they estimate are technically and financially capable of providing the FPSOs, and only allows those contractors to bid

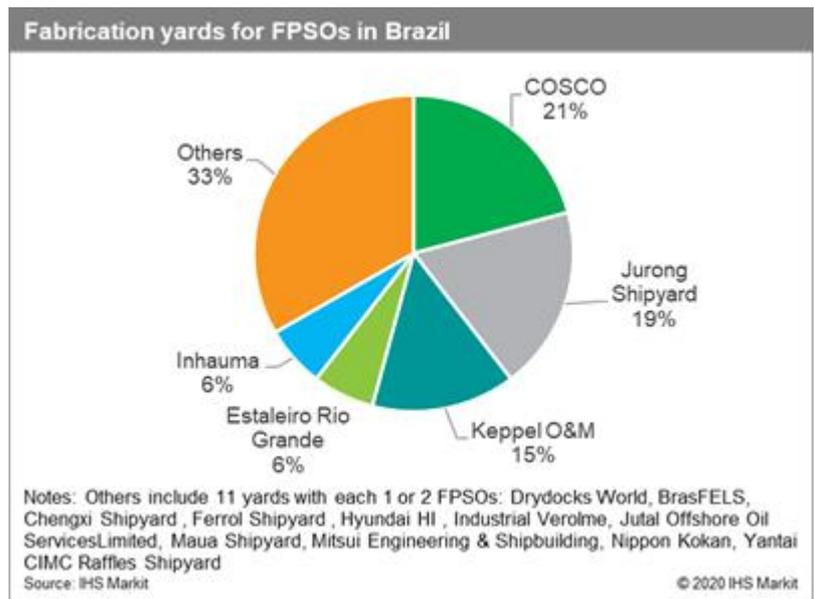
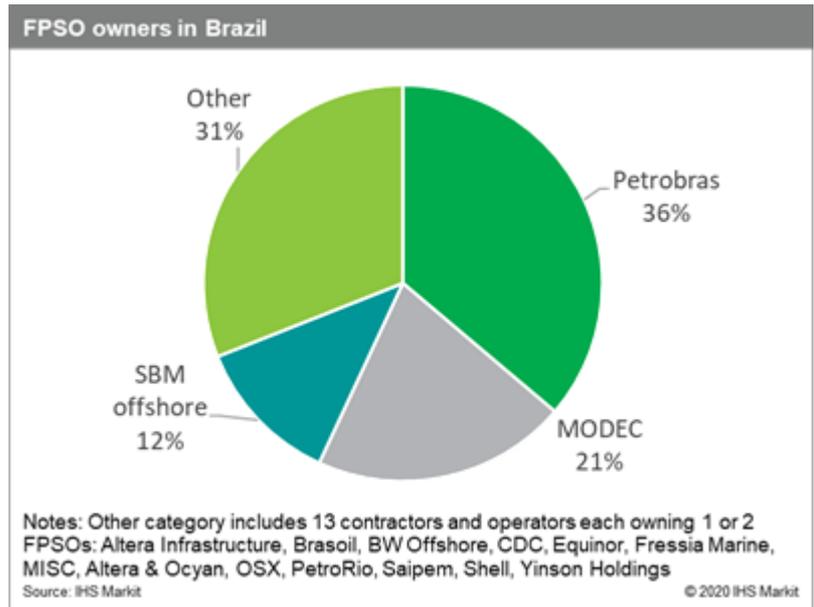
- **Conversion vs newbuilds**

Most of the FPSO fleet operating in Brazil are converted FPSOs, representing 87% of the total fleet. It is likely to remain this way as six out of nine units currently under construction are being converted. However, we could likely see more newbuild units if contractors with standardised units, such as SBM Offshore and its Fast4Ward programme, are successful in the region.

- **Water depths**

About 74% of the FPSO fleet operating in Brazil is found in deepwater ranging from 3,000 to 7,500 feet (914 m to 2,290 m). The rest is distributed between mid-water (20%), shallow water (4%) and ultra-deepwater (2%). There is only one FPSO operating in ultra-deepwaters; SBM's FPSO Esperito Santo at Shell's Ostra field.

FPSbase by IHS Markit anticipates that most of the future FPSO fleet will remain in deepwaters. At present, out of the nine units in the country's order book, seven will be deployed in deepwaters. The two remaining ones will operate at the Marlim Revitalisation projects, which are located in waters just under the 3,000 feet limit. The foreseeable demand



is also predominantly for deepwater units. There is no foreseeable demand for FPSOs in shallow waters and very little in mid-waters and ultra-deepwaters.

The high number of FPSOs operation in deep waters is specific to the Brazilian market. Indeed, regions across the globe have a higher number of FPSOs operating in mid and shallow waters and the only other region with a comparable proportion of FPSOs in

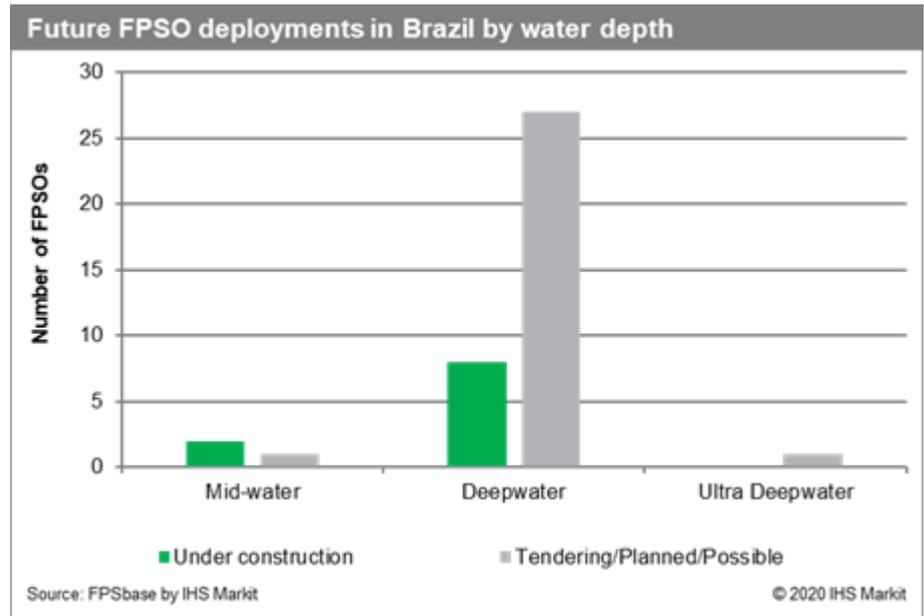
deeper waters is West Africa. Because of the differences in water depth but also regional weather conditions, FPSO designs will vary and one of the notable differences will be in the types of mooring for an FPSO. For instance, regions with calmer waters such as Brazil, will be primarily permanently spread moored.

- **Processing and storage capacities**

Brazil hosts a significant number of FPSOs with large processing capacities and storage capacities compared to other regions. More than half of FPSOs producing in Brazil can process over 150,000 b/d of oil and more than two third of the fleet can store over 1,500,000 barrels of oil.

Order book for Brazil

The year of 2020 has so far only recorded two new FPSO deployments starting production across the globe. One of the units, FPSO P-70, was deployed in South America at Petrobras' Atapu 1 project, offshore Brazil. The FPSO is capable of processing 150,000 b/d of oil and 6 MMcm/d of gas. As for next year, three FPSOs are scheduled to come online in Brazilian waters, with all units destined to Petrobras-operated projects. FPSO Carioca MV30 will be deployed at the Sepia project, FPSO Guanabara MV31 at the Mero project and FPSO P-71 at the Itapu project.



FPSO order book for Brazilian projects				
FPS Name	Owner	Operator	Field	Onstream
Carioca MV30 (Sepia)	MODEC	Petrobras	Sepia (Nordeste de Tupi)	Mar 2021
FPSO Guanabara MV31	MODEC	Petrobras	Mero (Libra)	Apr 2021
Almirante Barroso MV32	MODEC	Petrobras	Buzios (Franco)	Aug 2022
P-71	Petrobras	Petrobras	Sururu (ex-lara)	Dec 2022
Anita Garibaldi MV33	MODEC	Petrobras	Marlim	Dec 2022
Sepetiba (Mero 2)	SBM	Petrobras	Mero (Libra)	Feb 2023
Anna Nery	Yinson	Petrobras	Marlim	Mar 2023

FPSO order book for Brazilian projects

FPS Name	Owner	Operator	Field	Onstream
Marechal Duque de Caxias	MISC	Petrobras	Mero (Libra)	Apr 2024
Bacalhau (FEED Plus)	MODEC	Equinor	Bacalhau	Aug 2024

Source: FPSbase by IHS Markit

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Demand in Brazil

The South American market remains the main driver for FPSO demand in the near term but also in the long term as the region represents 40% of the total visible demand.

- **Recent awards in the Brazilian FPSO market**

One firm FPSO award was announced in the second half of 2020 in the South American market as Petrobras signed an LOI in August with MISC to charter the FPSO Marechal Duque de Caxias for the Brazilian Mero 3 project. The charter and service agreements are of 22 and a half years. The FPSO will be designed to process 180,000 b/d of oil and 12 MMscm/d of gas. First oil is scheduled for the first half of 2024. Earlier this year, Equinor and MODEC signed a sales and purchase agreement to supply an FPSO for the Bacalhau project, offshore Brazil. The contract is based on a two-step award, with first the FEED and pre-investment and then, an option to progress with an EPIC contract when FID is taken.

FPSO awards in Brazil since 2017

Project Name	FPSO	Contractor	Operator	Status	Start-up
Sepia 1	Carioca MV30	MODEC	Petrobras	Leased	Mar 2021
Mero 1	Guanabara MV31	MODEC	Petrobras	Leased	Apr 2021
Mero 2	Sepetiba	SBM Offshore	Petrobras	Leased	Feb 2023
Buzios 5	Almirante Barroso MV32	MODEC	Petrobras	Leased	Aug 2022
Marlim Revitalisation 1	Anita Garibaldi MV33	MODEC	Petrobras	Leased	Dec 2022
Marlim Revitalisation 2	Anna Nery	Yinson	Petrobras	Leased	Mar 2023
Bacalhau	Bacalhau	MODEC	Equinor	Owned	Aug 2024
Mero 3	Marechal Duque de Caxias	MISC	Petrobras	Leased	Jan 2024

Source: FPSbase by IHS Markit

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- **Upcoming awards**

No awards are expected to be announced for the rest of the year. However, FPSbase by IHS Markit estimates that up to 11 FPSO awards could be announced in 2021 in South America, of which nine are for FPSOs destined to Brazil.

Petrobras could likely award up to six contracts next year. The operator is planning to award a lease contract for the FPSO Parque das Baleias Integrado for which it launched a new tender in October this year. The project was just before the relaunch postponed by a year and the previous bidding process for the FPSO charter was cancelled. The FPSO will be capable of processing 100,000 b/d and will be chartered for 22 and a half years. Interested companies are expected to submit bids by 17 March 2021. First oil is now expected in 2024.

Other potential awards by Petrobras for next year include three FPSOs for the Buzios field. The first of the three new units will be the FPSO Almirante Tamandare, which will be deployed at the Buzios 6 project and will be the largest production unit to operate in Brazil once onstream. Petrobras has started negotiations with SBM Offshore for the lease of the latter FPSO, which will have capacity to process 225,000 barrels of oil and 12 million cubic metres of gas per day. First production is scheduled for the second half of 2024. The other two FPSOs will be deployed at the Buzios 7 and Buzios 8 projects. The two units will be owned by Petrobras, contracted under an EPC contract, and will be named P-78 and P-79. Both FPSOs will be capable of processing 180,000 b/d of oil and 7.2 MMcm/d of gas. Petrobras has launched a tender for the provision of the P-78, with bids expected on 18 December 2020. The contract calls for the provision of "at least" one FPSO, giving contractors the option to submit proposals for an additional FPSO, which would be the P-79. Start-up is planned for 2025.

Petrobras is also likely to award FPSO contracts for the Mero 4 project for which tendering was launched in March 2020. The FPSO will have capacity to process 180,000 barrels of oil and 12 million cubic metres of gas per day.

Other operators that could potentially generate awards in Brazil, include Shell with the Gato de Mato project, Karoon Gas with the Neon project, and Enauta with the Atlanta FDS project. The tender for Shell's project was launched in May 2019 and is yet to be awarded. The operator is looking for an FPSO with a process capacity of 90,000 b/d of oil. Karoon Gas is carrying out studies for the Neon development and is considering redeploying Altera Infrastructure's FPSO Piranema Spirit. As for the Atlanta FDS project, Enauta is evaluating whether to take on partner Barra Energia's share or to abandon the field. A decision is likely to be taken by the end of November 2020. The FPSO is planned with an oil processing capacity between 50,000-70,000 b/d. Meanwhile, BW Energy has pushed back FID on the Brazilian Maromba project to the first quarter of 2022. The operator is at present reviewing the project and evaluating FPSO candidates for a potential redeployment.

Potential FPSO contract awards in Brazil in 2021

Project	Operator	Country	Potential Award	Onstream	WD (ft)
Atlanta FDS	Enauta	Brazil	2Q 2021	3Q 2023	5,085
Gato do Mato	Shell	Brazil	2Q 2021	3Q 2023	6,598
Buzios 6	Petrobras	Brazil	2Q 2021	1Q 2024	6,234
Neon	Karoon Gas	Brazil	3Q 2021	4Q 2023	1,001
Buzios 7	Petrobras	Brazil	3Q 2021	3Q 2025	6,562
Sergipe de Aguas Produndas	Petrobras	Brazil	4Q 2021	4Q 2024	4,593
Parque das Baleias	Petrobras	Brazil	4Q 2021	4Q 2024	4,921
Mero 4	Petrobras	Brazil	4Q 2021	4Q 2025	6,444
Buzios 8	Petrobras	Brazil	4Q 2021	4Q 2025	6,562

Source: FPSbase by IHS Markit

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Challenges in the FPSO market

- *Changes in the oil price:* Fluctuations in the oil price was and remains a major challenge for the FPSO market as many projects were either delayed or cancelled after the oil price started to drop at the end of 2014.

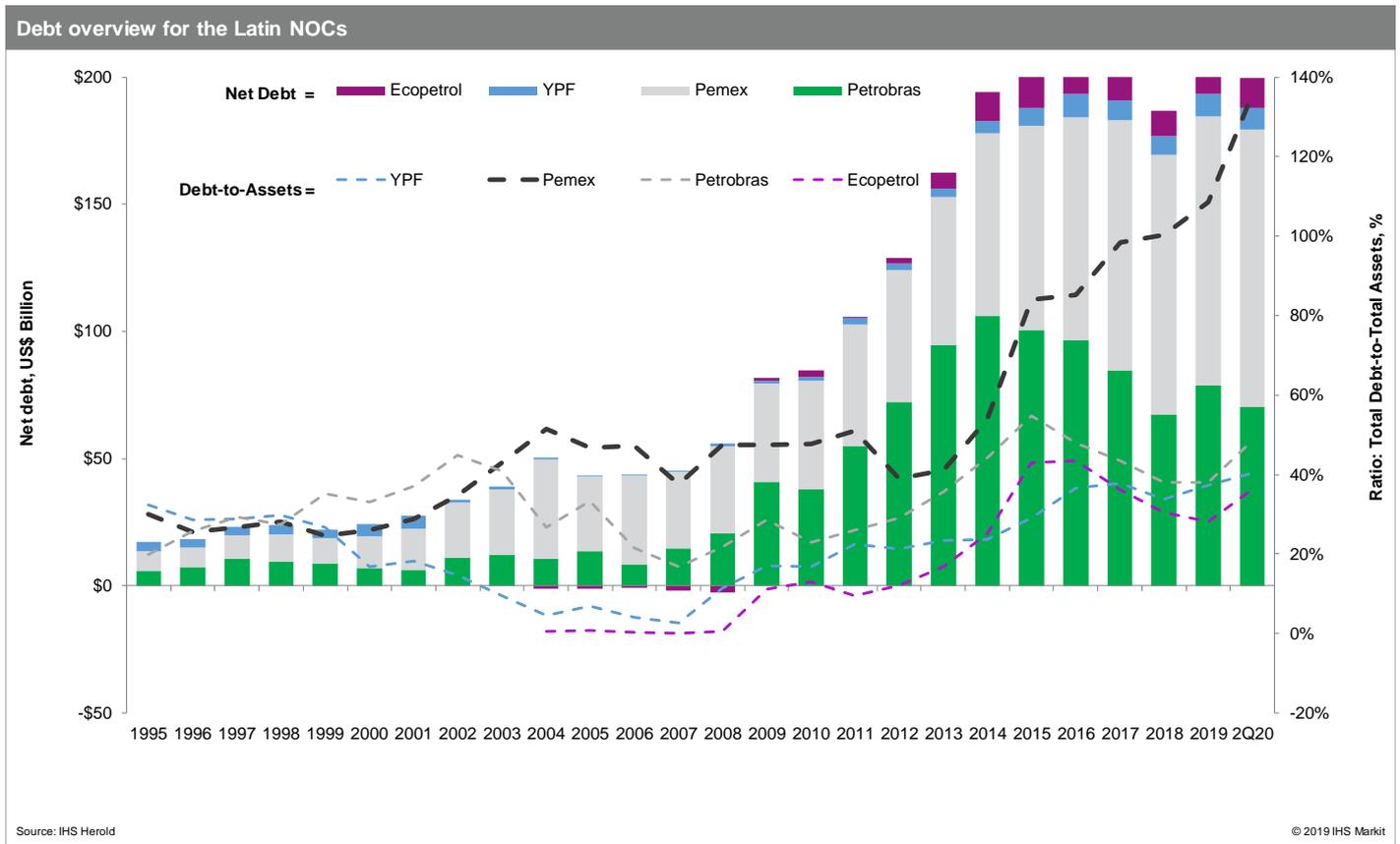
- *Changes in development plans:* Operators changing their development plans to a subsea tieback to existing infrastructure instead of a standalone development is also a challenge for FPSO demand numbers. This is however more observed in established regions where tieback opportunities are more present.
- *Unforeseen events:* The timing of projects can quickly be affected by any unforeseen changes caused by the host country's political, geopolitical and legal landscape.
- *Bottleneck at yards:* This might become an issue as the number of FPSO contracts increases, which will potentially tighten the capacity of yards and incur delays in delivery.
- *Finance issues:* FPSO projects could be cancelled or delayed due to operators having challenges securing financing.
- *Shift in cleaner energy:* It is possible that the shift towards renewable energy will have an impact on the FPSO market but also the Oil and Gas market in general, as operators are diversifying towards renewable energy. It might also mean that it's harder to secure financing as banks want to be associated with sustainable forms of energy.

E&P Projects Economic Feasibility

Vantage service

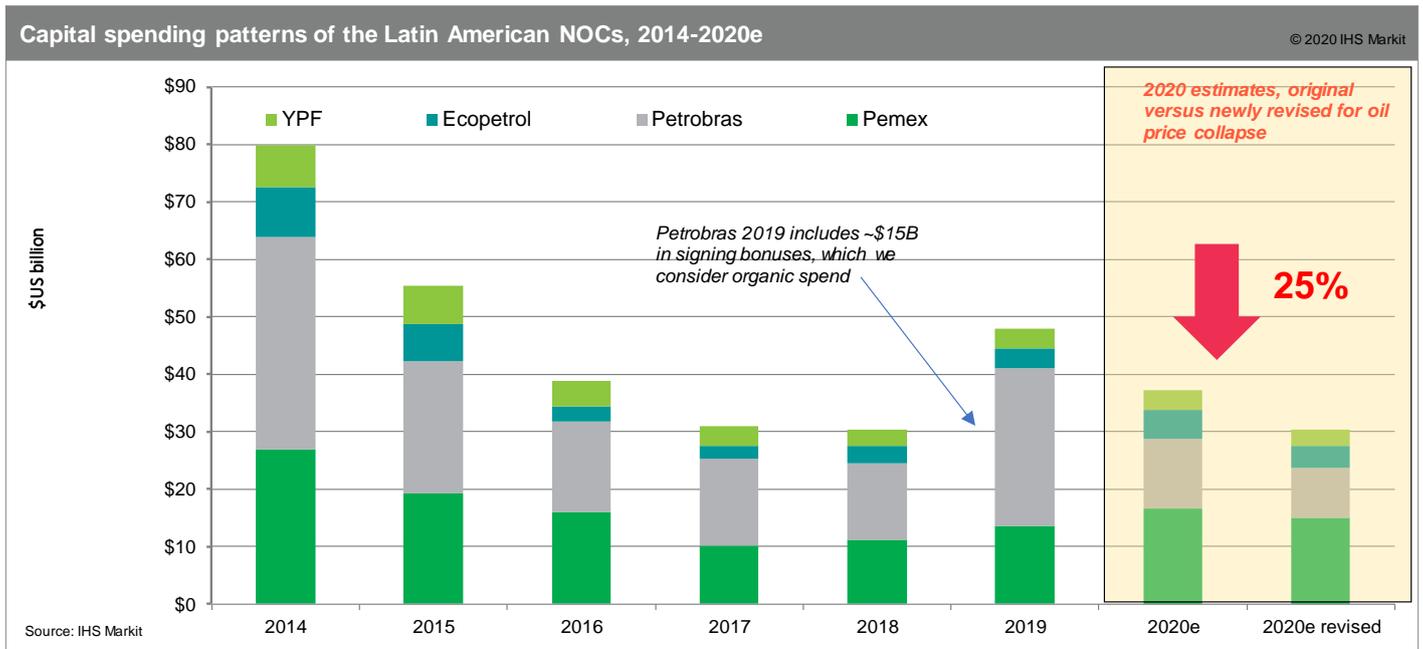
Net debt is on the rise

For the National Oil Companies (NOCs) in Latin America, managing debt levels becomes important as investors continue to push for capital discipline and better returns on investments. Net debt has increased consistently between 2010 and 2019, with the only year-on-year drop observed in 2018. The total-debt-to-total assets percentage has trended similarly upwards, with PEMEX taking on more debt than any of the other NOC's in the region. Petrobras was the most indebted oil company in the world during the early part of this decade, however, the company has since focused on improved corporate governance and improved financial health, and consistently reduced its debt since 2015. Petrobras divested close to US\$16 billion in non-core assets in 2019 and plans to divest anywhere in the range of US\$20 to US\$30 billion between 2020 and 2024. These asset divestments have played an important role in the reduction of debt levels for the company.



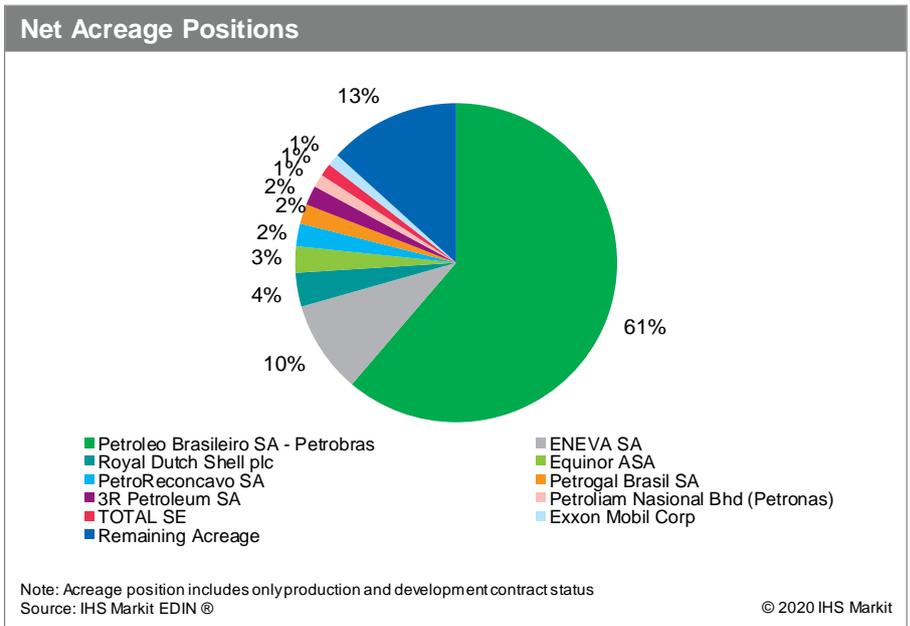
Capital revisions were seen throughout 2020

While capital expenditure declined post 2014, the Latin American NOCs were among the few peer group companies around the world that had planned higher spending in 2020 (excluding the approximate spend of US\$15 billion in signing bonuses by Petrobras). However, with Covid-19 and the stress on commodity prices, these planned capital expenditures have been revisited multiple times throughout the year and to date we have seen a 25% reduction from the Latin American NOCs in comparison to their initial plans at the start of 2020. Latin American exploration and production companies, other than the NOCs, have been more aggressive in their capital expenditure revisions. They have announced reductions up to 40% when compared to their initial plans at the start of 2020.



Petrobras leads activity in Brazil

Petrobras has the maximum acreage available for exploration and development in Brazil. Taking into account the acreage that is currently under development or producing, more than 60% of it is owned by Petrobras. Other companies such as Shell, Equinor, TOTAL, Petronas and Exxon Mobil also hold sizable acreage positions in the country.

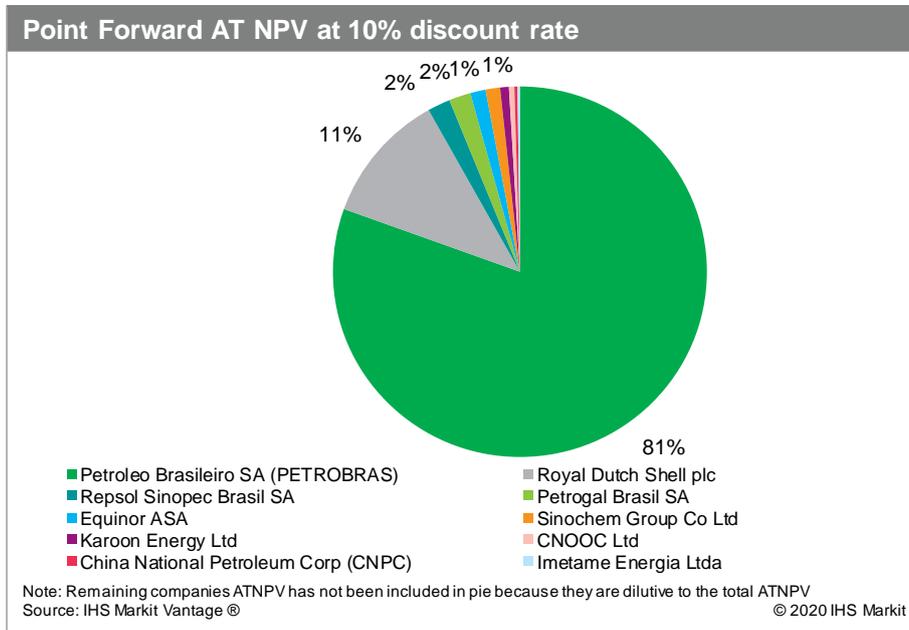


For acreage under development and/or production, Equinor’s share is quite

evenly divided between the Campos and the Santos Basin. Shell has almost 80% of its acreage positions in the Santos Basin. Exxon Mobil and TOTAL have 100% and 88% ownership in the Santos Basin respectively. For Petrobras the distribution of acreage between Campos and Santos Basin is pretty even, with the company owning acreage in almost all other basins in Brazil as well.

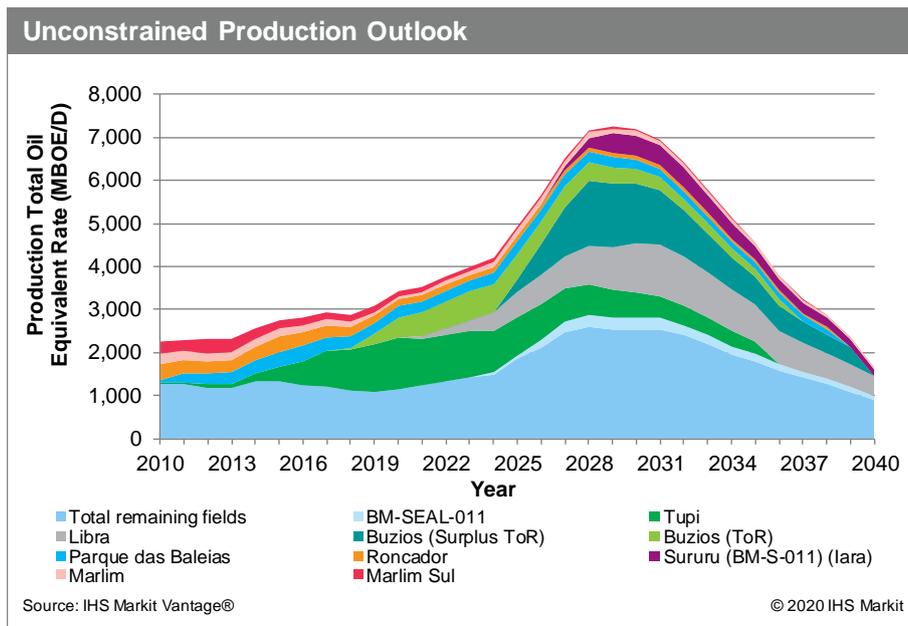
Asset valuation analysis, taking into consideration point-forward After Tax Net Present Value (ATNPV) for all fields where development or production is ongoing, highlights that most of the value creation gets generated and allocated

towards assets owned by Petrobras. Companies looking to enter Brazil or increase their presence in the region might benefit from strategic partnerships with the company. A prime example of success is Roncador field in the Campos Basin. The working interest for the field is split 75% and 25% between Petrobras and Equinor respectively. Both partners have benefited from this partnership where Petrobras has gained access to the improved oil recovery experience from Equinor and at the same time, Equinor has gained access to the reserves of one of the largest producing fields in the country.



Production outlook is growing in the near future

We expect the unconstrained production outlook for Brazil to be strong and show significant growth in the near future. The unconstrained production outlook is built taking into account company provided guidance on investments and expectations, without considering the demand constrains. Also, this production outlook includes our assumptions on fields that might come online beyond 2025, not just those mentioned by the operators in the country. Based on these assumptions, production in Brazil is expected to reach close to 7,000 MMBOE/D by 2028 in this unconstrained outlook, led by fields such as Buzios, Libra and Tupi.

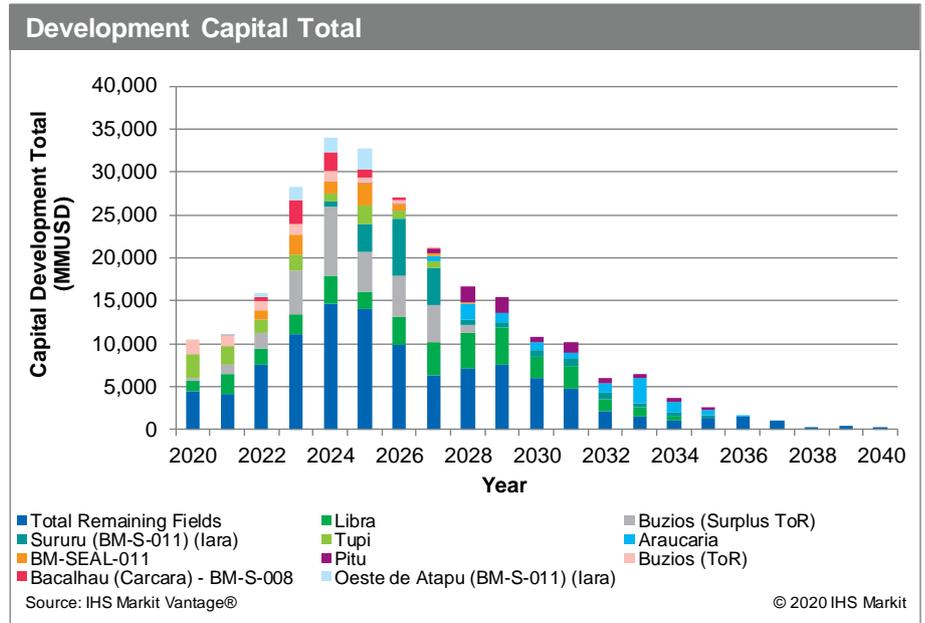


In comparison to other Latin American countries, the unconstrained production outlook for Brazil has a strong growth forecast out into the next decade. The contrast is clear when looking at countries such as Colombia and Mexico. Both countries showcase a declining outlook for production and should be expected to focus on finding new opportunities or revitalizing of existing assets to keep supply steady. In Colombia, for example, companies might have to start looking at accelerating investments for improving the recovery factor of existing fields where infrastructure already exists so that they can lessen the burden of finding new investment dollars.

In Brazil, we are expecting close to 50 fields to start producing between 2020 and 2030. Fields such as Atapu, Bacalhau (Carcara), Gato do Mato, and Pitu are all expected to start producing in this time period.

Capital investments expected to rise as pre-salt fields are developed

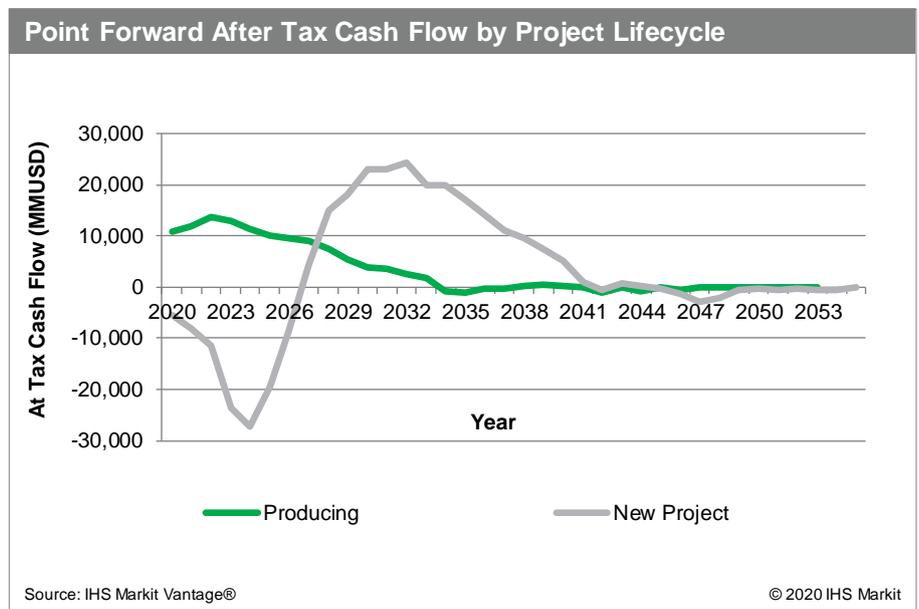
We expect capital invested towards development of fields in Brazil to start increasing over the next couple of years, until fields such as Buzios Surplus TOR and Sururu push investments to its peak right around the middle of the next decade, in 2024 and 2025. From a company perspective, investments are expected to be led by companies like Petrobras, Shell, TOTAL, Equinor and Exxon Mobil. Exxon Mobil’s investments are driven primarily by Bacalhau. Shell’s investments are being driven by fields such as Tupi and Libra, where investments are expected all through the next decade, along with fields like Gato do Mato, where investments are expected between now and 2025.



Total investment over the next decade is expected to be close to US\$220 billion. The deepwater fields could present development challenges and could drive costs up, but the large reserves size warrants independent development. For such large fields, as has been observed in other instances, it is assumed that a large number of wells would be predrilled in order to meet the quick ramp up of production.

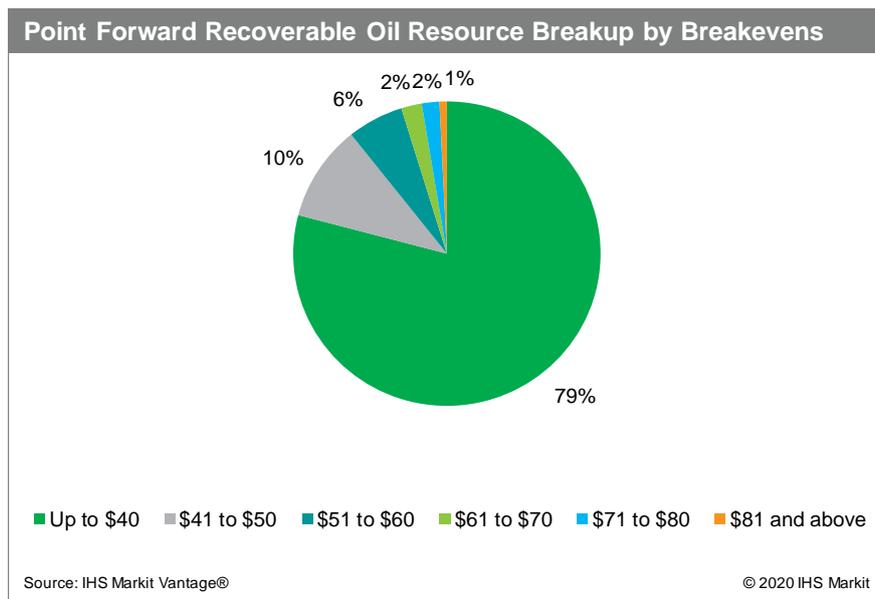
Point forward cash flow generation expected to be positive overall

We expect in general, both producing and new projects to contribute positively to the overall point forward after-tax free cash flow (ATFCF) generated from this activity. While point forward ATFCF from existing producing fields might start tempering down towards 2035, new projects are expected to kick into high gear by 2026 and provide substantial positive cash flow all the way to 2040.



The point forward ATFCF for the new projects stays in the red for a few years, a reflection of the capital investments going into the development of these fields. However, the point forward ATFCF generated for the next 15 years is expected to be close to US\$200 billion as per our analysis. In comparison, over the next 20 years, point forward ATFCF generation from Colombia is expected to be close to US\$39 billion, Guyana is expected to be around US\$80 billion and for Argentina is expected to be approximately US\$44 billion. The fields in Brazil provide a wide spectrum of opportunities for the investment community, as there exists the optionality to participate in existing producing fields as well as new developing fields which are expected to provide strong cash flow into the future. A good example is the existing portfolio of Equinor's assets in Brazil, where fields such as Roncador and Peregrino are currently providing positive cash flows and fields such as Bacalhau (Carcara) are expected to start contributing towards positive cash flow by 2025.

When we compare the oil recoverable resource number from the oil fields in Brazil and categorize them by point forward breakeven, almost 80% of the recoverable oil resource has a breakeven price of US\$40/bbl and below. This puts the fields in Brazil in a coveted position and we expect continued interest from the international community looking for investment opportunities around the globe.

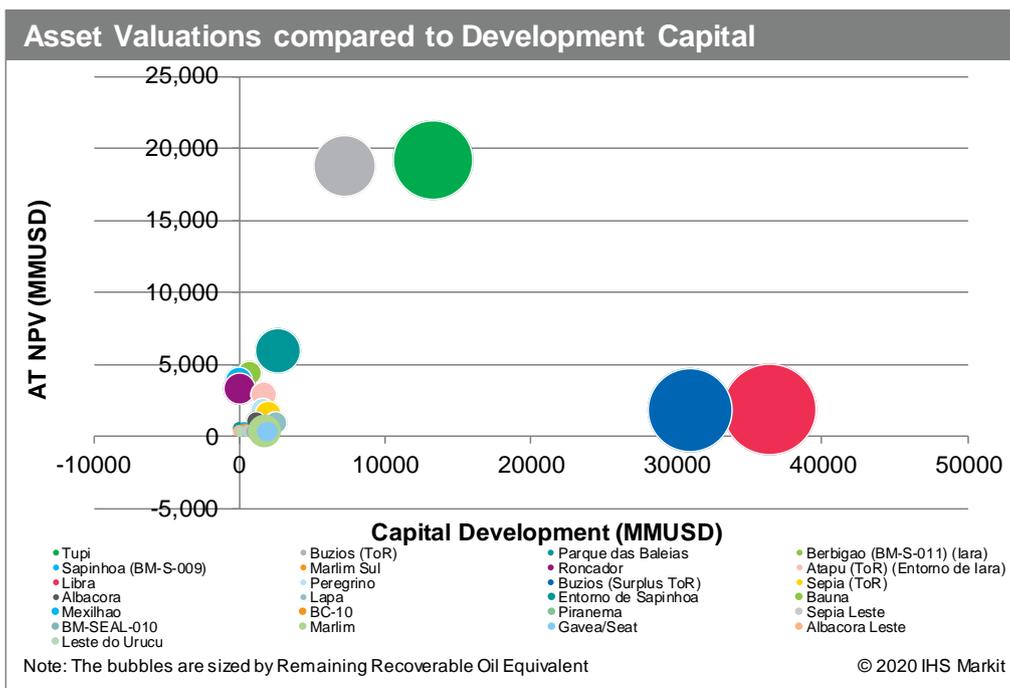


Asset valuations will strengthen as capital expenditure commitments decrease in the future

When we compare the development capital expenditure to the point forward ATNPV for the assets in Brazil, the point forward ATNPV of the assets improve significantly as the capital commitments start to decline.

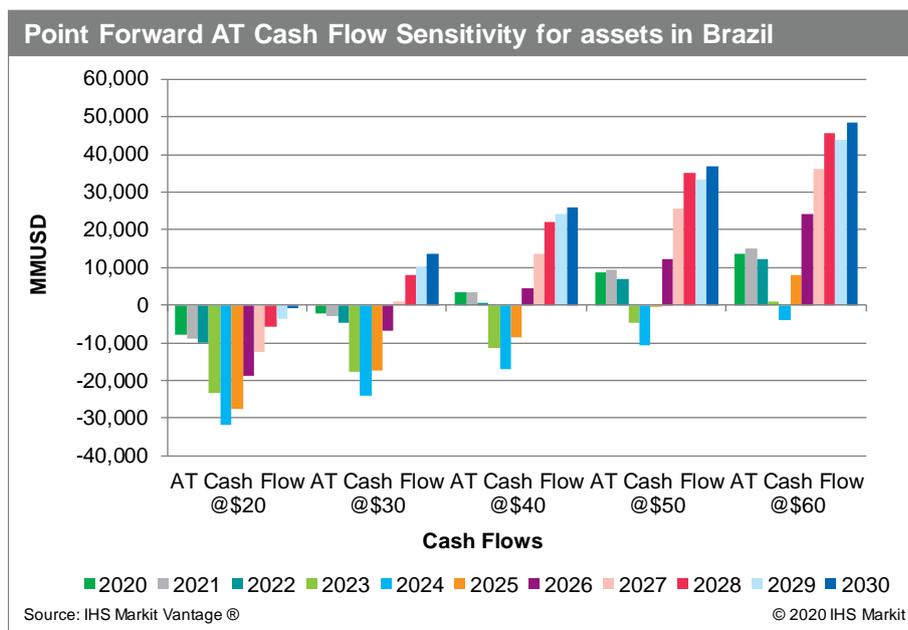
As an example, let us consider the Buzios block. Buzios Surplus TOR and Buzios TOR assets are a part of the Buzios contract block. The whole field, including the volume under the Transfer of Rights (ToR) agreement is expected to

hold between 6 to 10 billion recoverable barrel of oil equivalent. The Buzios project is currently the biggest Petrobras project under development and a key asset in its portfolio. While the field does showcase high level of contaminants, the wells under production have great productivity, thus decreasing the number of wells needed to reach platform production capacity, and thus help reduce cost to an extent. Buzios ToR has been producing since 2018, and we expect Buzios Surplus ToR to start producing from 2025. Capital investments in Buzios TOR started around 2013 and investment of approximately US\$5 billion is expected between 2020 and 2025. In comparison, capital investments in Buzios Surplus TOR are expected to be close to US\$20 billion during the same time period. As capital commitments decreased in Buzios TOR over the years, and production ramped up the point forward ATNPV of the asset has seen tangible improvement, and similar behavior could be expected from the Buzios Surplus TOR asset as well.



Brazilian assets showcase higher sensitivity to commodity price fluctuations

Commodity prices continue to impact investment decisions and returns for oil and gas projects across the globe and Brazil is no exception. While most new projects in the Pre-Salts showcase a competitive breakeven price, prolonged depression of oil prices can create a dent in the ATFCF and the ATNPV of the assets in the country. A sensitivity analysis of the point forward ATFCF for the assets in Brazil at various oil prices highlights that at US\$20/bbl, the ATFCF stays in

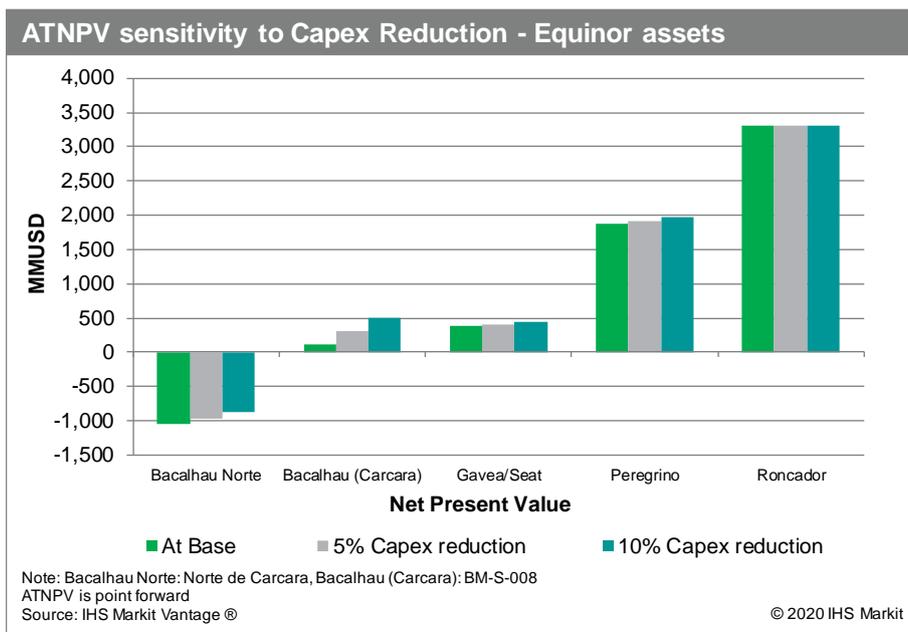


negative territory all the way to the end of 2030. However, with a change in price to US\$30/bbl, the ATFCF moves into positive territory by 2027. Just between 2027 and 2030, this price change creates cumulative positive cash flow of US\$32 billion. At US\$60/bbl, the assets create close to US\$250 billion in ATFCF, a significant upward movement from US\$20/bbl mark. This sensitivity analysis highlights that while Brazilian assets require huge capital commitments, the assets can also provide strong cash flow to a company's portfolio after a certain oil price threshold is broken.

Reduction of capital and operating expenditure has material impact on ATNPV

Since 2014, companies around the world have focused on costs and deployed various technologies and procedures to reduce costs and improve returns for all kinds of investors and shareholders of oil and gas companies. Companies in Brazil too have focused on this and have managed to trim costs down over the past five years. With the current challenges the industry faces, companies are yet again being asked to revisit and reevaluate costs and try to identify means to reduce it.

A sensitivity analysis around reduction of capital and operating expenditure leads to the conclusion that even a 5% to 10% change in costs can impact the point forward ATNPV of the assets in Brazil and improve the overall returns for the partners involved. Equinor, Exxon Mobil and Petrogal Brazil share working interest in the Bacalhau (Carcara) field. A 5% and a 10% reduction in capex moves the point forward ATNPV of the asset upwards from around US\$110 million dollars to more than US\$300 million and US\$500 million respectively. These point forward ATNPV's are calculated at an oil price assumption of US\$40/bbl. In other words, a 10% drop in capital expenditure can lead to a +300% movement in the point forward ATNPV of an asset. On the operating expenditure side, a 10% drop in operating expenditure moves the point forward ATNPV of the Peregrino assets from US\$1.8 billion dollars to US\$2 billion dollars.



Brazil has world class resources and opportunities

An economic analysis of the oil and gas fields in Brazil highlights that the recoverable resources of the fields are very competitively stacked globally, with a majority of them capable of being developed under and around the US\$40/bbl threshold. The fields will require long term capital investment commitments but at the same time are also capable of generating long term positive cash flow for the partners. The unconstrained production outlook is expected to be strong and even grow in the near future. And while the point forward ATFCF and the ATNPV of the fields showcase high sensitivity to the commodity price swings, they also indicate that for operators with deep pockets and capacity to absorb the impact of a downturn, the upsides could be highly attractive.

Oil and Gas GHG Emissions

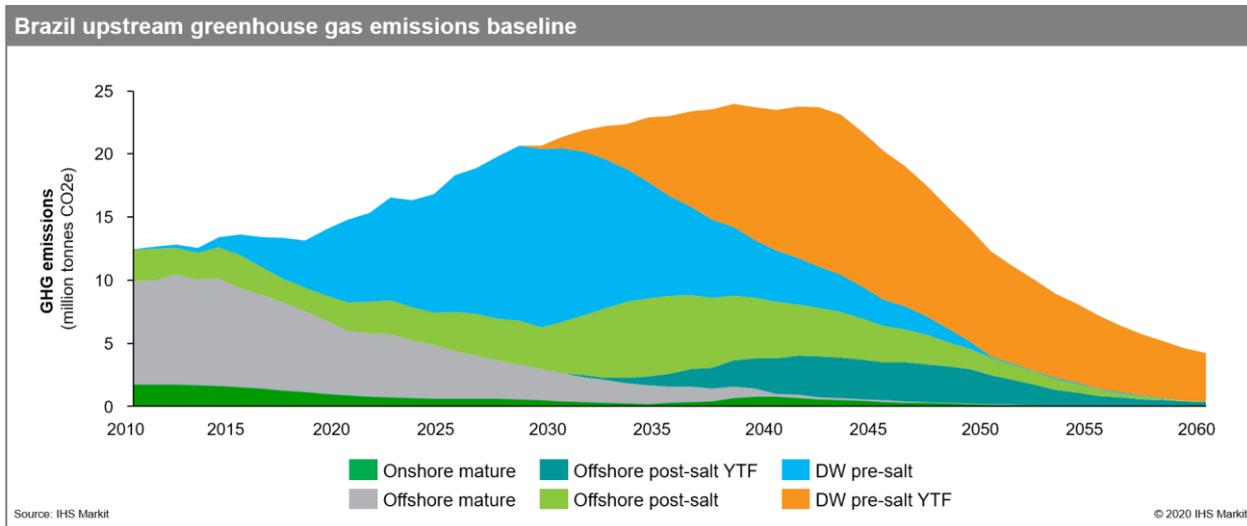
Upstream Technology and Innovation service (UTAI)

Technology-enabled Opportunities to Manage Oil and Gas GHG Emissions

The oil and gas industry is coming under increasing pressure to reduce costs and raise efficiencies to remain competitive in an evolving energy landscape. At the same time, stakeholder scrutiny is growing over greenhouse gas (GHG) emissions associated with core oil and gas operations. If the industry is to maintain its prominent role in the global energy mix and protect its license to operate, it will need to substantially lower its carbon profile. IHS Markit sees technology and broader forms of innovation as very much at the heart of these efforts.

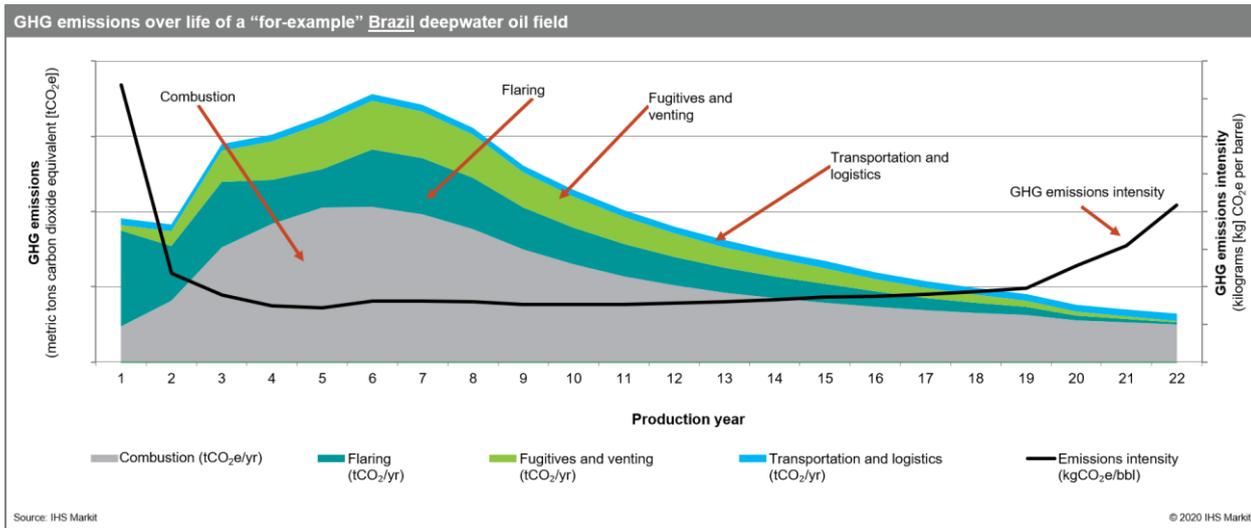
These dual industry pressures are playing out with equal force in Brazil. The substantial rise in oil and gas production anticipated over the coming decades is at least partly contingent on managing costs to be able to compete for scarce capital on the global stage. IHS Markit further projects that this production growth will be accompanied by about a two-third increase in total GHG emissions from the Brazilian upstream sector between now and the late-2030s (see Figure 1), assuming a continuation of current practices. This corresponding rise in emissions is not acceptable for many industry players pledging that their operations (largely Scope 1 and Scope 2 emissions) will be carbon neutral by 2030, and is creating a sense of urgency to act now.

Figure 1



In assessing where to prioritize carbon-reduction efforts, it is helpful to first understand the most significant sources of emissions. To develop such insights, IHS Markit modeled the GHG profile of a representative deepwater Brazilian oil field over its productive life (see Figure 2). It reveals that combustion (covering power generation and fuel use) is by the far the dominant contributor with 57% of total lifecycle emissions, followed by flaring with 23%, fugitives and venting with 15% and transportation and logistics with 5%. This analysis makes clear that carbon reduction efforts should primarily target or offset combustion-related emissions if they are to have any sort of meaningful impact.

Figure 2



IHS Markit presents a framework for considering the full range of technology-related opportunities the Brazilian oil and gas sector might pursue in the GHG emissions management space, categorized into separate “Tiers.” Such solutions span the oil and gas asset development and operations lifecycle, and are differentiated by several factors.

- **Tier 1 opportunities** are those ready for deployment today, able to deliver moderate-scale results in the near- and medium-term, and require minimal additional capital investment beyond minor facility instrumentation upgrades. They tend to focus on improved surveillance and the management of complex systems such as production and process networks, energy management, methane containment, and transportation and logistics.
- **Tier 2 opportunities** involve technologies that may be ready for deployment today, but would also benefit from ongoing refinements to improve their performance and lower their costs to be able to deliver moderate- to significant-scale benefits. Low- and zero-carbon power sources, electrification of devices, and upgraded equipment all fall into this category.
- **Tier 3 opportunities** are longer-term investments that require additional development to make them technically and/or economically feasible. While they are often the most capital-intensive and take longer to pay returns, initiatives such as carbon capture, utilization and storage (CCUS) and subsea developments offer the most significant potential to reduce oil and gas emissions.

Looking across this framework reveals some of the bridges that are forming to link broader oil and gas industry trends. Digitalization and automation are being touted by industry leaders as a means to raise industry performance, and they also serve as the foundation for Tier 1 and some Tier 2 opportunities that rely on frictionless access to asset performance data and advanced analytical tools to make sense of it. Additionally, nearly all of the identified opportunities (e.g., optimizing transportation networks, reducing fuel consumption) have significant cost savings qualities to go along with their emissions management benefits, demonstrating that reducing costs or reducing emissions doesn’t have to be an either-or prospect.

In selecting targets for initial focus, Brazilian operators should be sure that their efforts align with the areas of greatest opportunity. This means prioritizing emissions associated with power generation and fuel use, while also developing methods to mitigate flaring, venting, and fugitives. And indeed, there is early activity across the country in many of these key segments, with several industry-leading deployments. The challenge over the coming years will be to expand and build on these successes to begin to have a material impact on overall Brazilian oil and gas GHG emissions, including in the areas of:

- **Carbon capture, utilization and storage.** The oil and gas sector increasingly recognizes that CCUS at scale is needed to mitigate emissions from operations and to offset emissions from the use of its products. Toward that end, the industry is driving technology development across the full CCUS value chain, with an especially strong focus on capture technologies and integrated projects. Of the 21 large, integrated CCUS projects that have been deployed globally to date, one that stands out is the Tupi CO₂ enhanced oil recovery (EOR) initiative that employs a novel and compact membrane separation technology to capture the CO₂ volumes from the associated gas produced in the field and re-inject it to drive higher recovery rates. This effective deployment might serve as a model for greater expansion of the CCUS concept across the Brazilian oil and gas sector.
- **Low- and zero-carbon energy sources.** With power generation and fuel use representing over half of Brazil's upstream GHG emissions, even small reductions in this area can have big impacts. But the industry is not satisfied with just small reductions, and is instead looking to replace the gas turbines and diesel generators that largely fuel Brazilian oil and gas assets with alternate sources of low- and zero-carbon energy.

There has been a corresponding rise in oil companies deploying what IHS Markit terms *Field-based Renewable Energy* over the past few years. Constructing renewable energy projects adjacent to oil and gas facilities to power operations, or tapping into electric grids fed by the same zero-carbon energy sources (e.g., solar, wind, hydroelectric, geothermal) can dramatically lower an asset's carbon profile. The 5 megawatt (MW) offshore wind project that Petrobras announced in 2018 to partially power its Ubarana field is a leading example in Brazil.

- **Energy efficiency.** There is more than one way to reduce the carbon-intensity of power generation and fuel use. Taking a cue from parallel digitalization-enabled initiatives, oil companies are beginning to proactively monitor critical equipment and overall production systems to ensure optimal energy use, and taking steps when they fall outside such sweet spots (without negatively impacting production). Installing microgrids in conjunction with traditional gas turbines and diesel generators is another way to raise energy efficiency. Even industry-leading companies have been able to reduce consumption by 5 to 15 percent through these means, and the expectation is that Brazilian assets could see similar if not greater results.
- **Methane emissions management.** Oil companies are increasingly cognizant that their old ways of calculating methane emissions from field development and operations activities by relying on standard engineering factors may not accurately reflect actual asset conditions. This issue is taking on greater urgency as technologies are

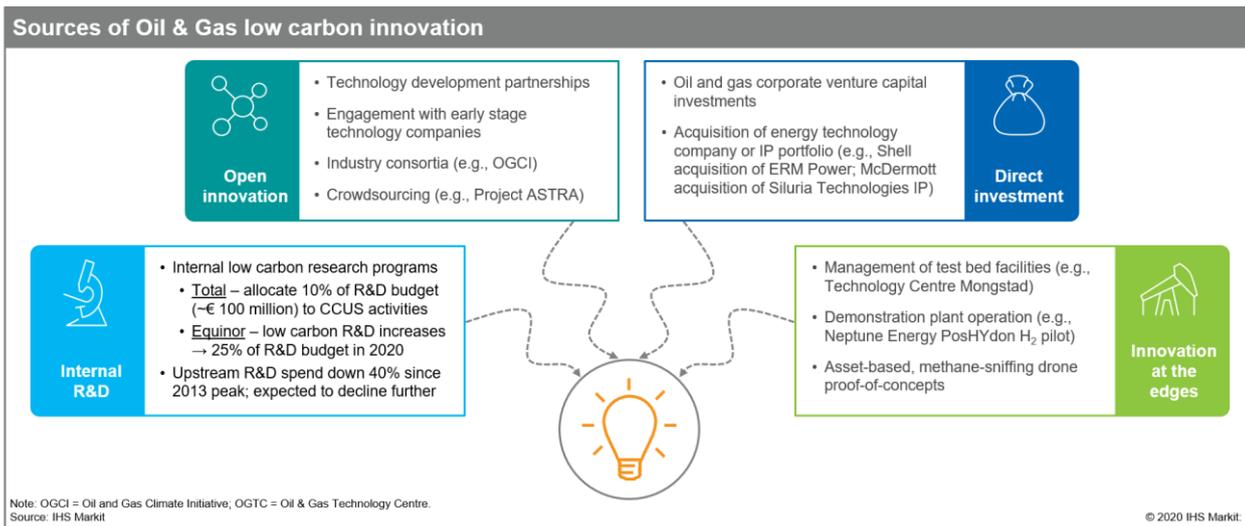
becoming more readily available (e.g., mobile cameras, satellites) that allow various stakeholders to peer “over the fence line” to detect and publicize major methane leaks.

To begin to develop a more accurate and quantified view of unintended methane releases, oil companies are leveraging a suite of complementary surveillance technologies. Fixed sensors, along with mobile ones installed on drones, airplanes, and satellites, can alert operations staff to existing or impending methane releases, and then link to maintenance management systems to automatically initiate repair activities. Although it remains difficult to definitively quantify an asset’s methane emissions baseline and the reductions achievable through the effective application of technology, IHS Markit estimates that a 20 to 40 percent reduction target is possible and reasonable.

IHS Markit analyzed the potential benefits that oil companies could realize from effectively applying the above technology-led solutions (and others from its *Upstream GHG Emissions Reduction* framework) to three main classes of Brazilian upstream oil and gas resources — deepwater pre-salt, offshore post-salt, and onshore mature. By modeling the operational and emissions characteristics of each and then applying the emissions reduction potential available from the range of solutions, IHS Markit calculates a nearly 60 percent drop in GHG emissions versus our established baseline. This significant reduction can be expanded even further through onshore CCUS projects, higher levels of electrification, and an increase in subsea developments. It’s interesting to note as well that the 60 percent reduction matches closely the projected two-thirds rise that would accompany the upcoming growth in production, enabling Brazil to keep its upstream GHG emissions nearly flat over the upcoming period.

As the industry looks to advance its technical capabilities in these low carbon areas, it’s finding that old innovation models don’t always work best. The oil and gas sector has traditionally viewed technology as a source of significant competitive differentiation, and has thus tended to develop proprietary solutions through internal research and development (R&D) centers and arms-length relationships with oilfield services and equipment (OFSE) providers and academic institutions. This attitude is shifting as oil companies seek more cost-efficient and effective ways to source needed technologies (see Figure 3), and it is especially pronounced in the low carbon space where companies are stepping outside their traditional domains of expertise, that attracts significant sources of alternate funding, and where collaborations between multiple parties with complementary capabilities often prove most effective.

Figure 3



Conclusions:

It is probably not too strong a statement to say that the oil and gas industry is at a critical juncture. With modest commodity prices projected for years to come and mounting climate-change concerns, industry players must find ways to lower their cost structures even further while substantially reducing the carbon footprints of their assets. A portfolio of digitalization- and broader technology-related solutions is increasingly proving themselves in a range of oil and gas asset and operating settings.

It is good to mention that some opportunities for service providers and related are listed below:

1. Technology – New Technologies using ML, Machinery and Technology Equipment in the Energy Space with Renewables;
2. Water Usage Technologies
3. Carbon Emission Technologies
4. EOR Technologies for Mature Fields
5. OPEX reduction Technologies for PreSalt Fields
6. Exploration and Drilling HSE technologies.

With Norwegian suppliers at the fore of many such initiatives, it naturally makes sense to offer them in Brazil as well to address the country's potential rise in GHG emissions associated with its oil and gas production increases, and to thus serve as a global example of sustainable growth.

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