Norway Oil & Gas, tt_nrg and Saudi Arabia Oil & Gas

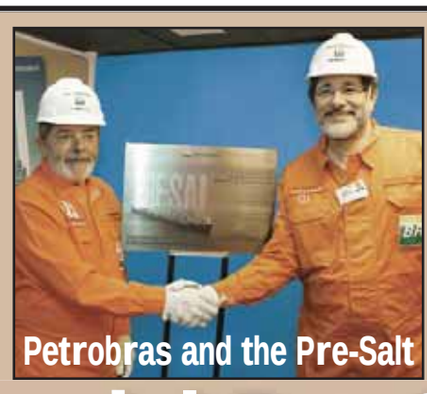
EPRASHEED
signature series

2010 – Issue 15

Brazil oil & gas

www.braziloilandgas.com


Carlos Fraga (Petrobras)


Petrobras and the Pre-Salt

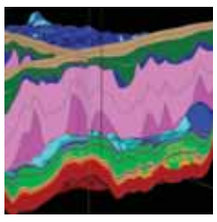
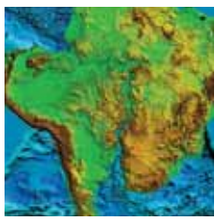

José Formigli (Petrobras)

Inside – Special Pre-Salt Issue


Edison Lobao, Minister of Mining and Energy, on exploring the Pre-Salt Accumulations

Francisco Stuckert



Dear Friends,

IPEX-Integrated Petroleum Expertise Co. is pleased to present itself to the petroleum industry E&P sector.

IPEX-Integrated Petroleum Expertise Co. is the total successor of HRT Petroleum, company which recently gave birth to two independent organizations: the new E&P operator HRT O|G and IPEX itself (consultancy and services).

The clarity of this separation is accentuated by the fact that former directors Marcio Rocha Mello, Tikae Takaki and Nilo Azambuja no longer share the administration, engaged as they are with the new operator.

By consequence, IPEX takes all functions of its predecessor, inclusive and chiefly, honoring all the ongoing contracts, agreements and projects. Besides that, IPEX proclaims its maximum endeavor to serve the industry with the same well known competence conquered by HRT Petroleum.

IPEX has its own corporate structure, with as CEO PAUL XU (MSc.). The company employs renowned specialists and professionals like Silvana Maria Barbanti (DSc.) Vladimir Oliveira Elias (PhD.), Paul Brooks (PhD.) and Giovanni Toniatti, and is keeping in its ranks a relevant part of the pre-existing team, without neglecting the hiring of new talents. IPEX is ratifying the current agreements with technical partners, such as Isotech, Weatherford, Fugro-Opeg, Stratageo, Biomarker Technology, Ucon Geoconsulting and GEMS among others, and engaging new high-end technical partnerships, to sustain the pledged standard of quality.

IPEX relies on its highly competent professionals to ensure the normal abidance of all activities. IPEX also asserts that its relation with the market will be conducted in a transparent manner, and in total respect to confidentiality.

In our site http://www.ipexco.com.br/ we exhibit, for the time being, a listing of the wide range of services, products, activities and consultancies offered in the domains of high resolution geochemical analysis, geochemical prospecting, remote sensing, basin modeling and biostratigraphy.

Paul Xu - *Chief Executive Officer*

ipex
Integrated Petroleum Expertise Co.

T. +55 21 3622-9500
F. +55 21 3622-9513
more.about@ipexco.com.br
www.ipexco.com.br

2010 – Issue 15

Brazil oil & gas

EPRASHEED
signature series

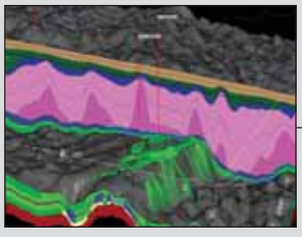
Contents

SPEECH ON THE PROPOSED NEW ACT REGULATING EXPLORATION IN THE PRE-SALT ACCUMULATIONS, BY EDISON LOBAO, MINISTER OF MINING AND ENERGY 6

PETROBRAS AND THE PRE-SALT ACCUMULATIONS 9
Interview with Petrobras E and P Executive Manager Pre-Salt – José Formigli

TECHNOLOGY PROGRAMMES: TECHNOLOGY HEADED FOR THE FUTURE 12
Interview with Carlos Tadeu da Costa Fraga, Executive Manager of CENPES.

A BOOST FOR DEVELOPMENT 20
Platforms P-51 and P-53 contribute to the revitalisation of the Brazilian shipbuilding industry and to the creation of jobs and income in Brazil, ensuring increased oil and gas production and development of the nation.



THE SUPER-GIANT PRE-SALT HYDROCARBON PROVINCE IN THE DEEP WATER SANTOS BASIN, BRAZIL 24
By Márcio R. Mello, Nilo C. Azambuja, Eduardo de Mio, André A. Bender, Carlos Luciano C. de Jesus and Priscila Schmitt – HRT Petroleum

BRAZIL – THE BIG BET 28
By Mauricio Girardello, PricewaterhouseCoopers

THE FALL OF THE OIL CURTAIN 30
An excerpt from The Hydrocarbon Highway, by Wajid Rasheed

Editors

Wajid Rasheed
wajid.rasheed@eprasheed.com
JC Cunha (Technology)
Majid Rasheed
Mauro Martins

Design

Sue Smith

United Kingdom

- Head Office
Tel: (44) 207 193 1602
- Brian Passey
brian@bspmedia.com
- Sally Cole
sally@bspmedia.com

Houston

- William Bart Goforth
william.goforth@eprasheed.com
Tel: (1) 713 304 6119

Brazil

- Ana Felix
afelix@braziloilandgas.com
Tel: (55) 21 9714 8690
- Josefina Filardo
jfilardo@braziloilandgas.com
Tel: (55) 11 9119 2104

Brazil oil & gas

www.braziloilandgas.com

Contribute to Brazil Oil & Gas during 2010

EPRasheed is looking for editorial submissions on the topics outlined in the editorial calendar. This can provide your company with the opportunity to communicate EP technology to the wider oil and gas community.

Please send abstracts or ideas for editorial to **wajid.rasheed@eprasheed.com**

Preference is given to articles that are Oil Company co-authored, peer reviewed or those based on Academic research.

Editorial 2010 Calendar

Jan/Feb	April/May	July/August	Oct/Nov
• Tupi & Subsalt • Deepwater and Subsea Technology • Cementing • LWD / MWD • Energy Efficiency • Smart Well Innovations • Real Time Operations • Software Consulting for Oil, Gas and Reservoirs Exploration	• Onshore Fields • Completion Technology • Smart Fluids • Formation Evaluation • Expandables • Tubulars • Drill-Pipe • Casing Drilling • Campos Basin & New Seismic Frontiers	• Petrobras President Interview • Reservoir Visualization • Extended Seismic Feature (4D, OBC, Wide Azimuth) • Reservoir Characterization • Well Intervention • Pipeline • Pigging and Pipeline Testing	• Multi-laterals • MPD Managed Pressure Drilling • Controlled Source Electro Magnetic • Zonal Isolation • EOR (PRAVAP) • Heavy Oil (PROPES) • Petrobras Offshore Construction • PROSAL Cenpes
Bonus Circulation			
	SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production 12-14 April 2010 Rio de Janeiro Brazil **72nd EAGE Conference & Exhibition/ SPE EUROPEC 2010** 14-17 June 2010 Barcelona Spain	**2010 Rio Oil & Gas** 13-16 September Riocentro Rio Brazil **SPE Annual Technical Conference and Exhibition** 20-22 September 2010 Florence Italy	
Special Publications			
	Petrobras Pre-Salt Technologies	Petrobras Technology III	

Speech on the proposed new Act regulating exploration in the 'Pré-Sal' accumulations, by Edison Lobao, Minister of Mining and Energy

Centro de Convenções Ulysses Guimarães – Brasília-DF – 31/08/2009.

"Mr President, I have the satisfaction and honour to present, in this memorable event, the result of the studies undertaken by the Interministerial Commission formed by President Lula to create a proposal for a new regulatory regime for the exploration and production of oil and natural gas for the country.

It was understood by Mr President of the Republic that, in view of the extraordinary discoveries of oil and gas in the offshore province known as the 'Pré-Sal', it became necessary and urgent that our petroleum legislation was updated, in the same way that other nations have done upon discovering large reserves within their territories.

For more than a year, following the directives of Mr President, the members of this Commission, along with Minister Dilma Roussef, have had the honour of coordinating and dedicating the best of their efforts and their intelligence to the most legitimate national interest in order to truly complete this mission according to His Excellency's wishes.

Apart from the Ministers of State Miguel Jorge, Guido Mantega, Paulo Bernardo and José Antonio Toffoli, the Presidents of BNDES and Petrobras, the Director-General of ANP, other participants and technical persons of the highest levels within various government sectors have all contributed to the format of the proposal that appears here today.

The work that we are presenting, and that will be subject to a wide ranging national debate is a result of profound studies of the current legislation for the sector for the majority of countries that produce and export oil, an analysis of the global economic situation and future scenarios and principally in defence of the interests of Brasil.

Our studies took their direction from the Federal Constituition article 20, which establishes: "They are assets of the Union (it's worth saying, the Brazilian population) the mineral resources, including those beneath the subsurface". Based on this constitutional precept, the new model proposes to benefit all Brazilians with the results of the exploitation of the riches of the 'Pré-Sal'. In this way, a policy of national development has been established with conditions of sustainability in order to avoid the situation where Brazil would become a mere exporter of oil without adding any development or wellbeing for its population.

Brazil urgently needs to transform itself into a developed nation, one that is modern and that overcomes inequalities and injustices that have for a long time required a solution. Based on this, what we present is the strengthening of the Federal pact through the distribution of riches with all states and muncipalities of the Federation.

The states and the muncipalities containing the area 'Pré-Sal' will have a different treatment. But the rest will need to be contemplated, because only in this way will balance be reached, readjusting the pact which is the foundation of national unity. It is precisely within this viewpoint that

the requirements of President Lula fit in. He envisages the exploration of these immense reserves as part of a strategic concept focused on transforming the country.

Background

The current legislation for activities in exploration and production of oil and natural gas is governed by Law nº 9.478, 1997, the well known Oil Law. When it was conceived, the Oil Law considered a scenario where the country had little production and had to import around 40% of consumed petroleum. The exploration of our sedimentary basins was therefore a high risk activity. The accompanying Oil Law mitigated this context, allowing investment and the evolution highlighted in the sector during the past decade.

In this period, the bids for oil and gas exploration and production marketed by the Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, had the following major objectives: safeguard the supply in response to increasing internal demand for oil and natural gas; replace and increase national reserves, with the goal of increasing future production; and decrease external dependence. These objectives were clearly achieved, when in 2006, President Lula communicated our self-sufficiency in oil production.

Current Scenario

In 2007, Petrobras announced the discovery of light oil and gas in the Santos Basin, with enormous potential reserves and good recovery prospects. Our sediments are located below a thick layer of salt in a region known as the 'Pré-Sal'. Of course, the discovery represented the possibility that Brazil could significantly increase its reserves in such a way as to cover the gap caused by internal demand and also position itself as an important exporter of petroleum.

A new horizon was revealed for the oil industry in the country. The expectation is that the new 'Pré-Sal' province will position Brazil among the top ten countries in terms of reserves of oil and natural gas. The short-term picture is highly promising; however, the technical and logistical challenges are gigantic, the large distances away from the coast; the depth of the reserves; the water depths and the thickness of the salt layer.

But Brazil has already shown that it is not afraid of challenges. The proof is in the exploration of Tupi, whose Long Duration Test started 1st May 2009. In 2010, the primary pilot will start operating and the definitive production system will commence in 2015. The exploration of the 'Pré-Sal' will require a monumental amount of resources which will constitute another challenge. But this does not frighten us. As a reflection of its political stability, there is a solid economy that has passed almost untouched through a devastating crisis and the security that it offers to the markets, Brazil is today one of the principal destinations of large investments.

Increasingly, public and private investors from many countries have sought us out to say that they are ready to invest in the 'Pré-Sal'. Today, Brazil is actually a widely respected and admired country that constitutes one of the most secure and trustworthy destinations for investors worldwide. We have in front of us the opportunity to create the conditions to promote development that requires the training of personnel and the procurement of goods and services of all kinds for sector productivity.

But, before this, it is worth recognising that in this context the current regulatory model does not permit the Government to promote the strategic management of exploration and production activities of oil and natural gas, which is of great importance to many economic sectors that are related to the oil industry. We need to remove all obstacles to the full development of the country. The current scenario is much more diverse than that of ten years ago.

Brazil has consolidated an industrial sector that is forward thinking and diversified. Petrobras is a solid company, one of the biggest in the world, with a high potential of capturing resources and excellent technical capability. After reaching 150 dollars, a barrel of oil has today stabilized at around 65 dollars. Notwithstanding the economic crisis, the world has an increasing demand for energy with oil continuing to be a major source of energy for the majority of nations. And what is more important is that global energy security depends on reliable suppliers. It is in this new scenario that the proposed changes are made to the oil and gas regulatory system.

Changes to the regulatory system

Worldwide, the contracting systems of exploration and production are the most diverse. Each country adopts the institutional arrangement that it judges is best for its interests. Exporting countries with large reserves of oil, as is the case of Brazil, prefer the shared regime. In Brazil, the concession regime exists which, as I confirm, was meant for a scenario that no longer exists.

In the understanding of the Interministerial Commission the model best suited to Brazil, considering the real prospects for the oil industry in the country, is undoubtedly the shared production regime. In order to retain ownership of the produced oil, in contrast to the concession system, the Government exercises greater management over production. Our proposal is that this regime be extended over other areas that have the same strategic characteristics as those found in the 'Pré-Sal' area, which is high upside and low risk. For other areas and those contracts already in existence it is important to show that the concession will be maintained. That establishes that extracted oil belongs to the concession holders through the payment of government shares.

The rules for the concessions will be maintained. The existing contracts are untouchable. In summary, it is worth restating: the new model is valid for the 'Pré Sal' areas that have not yet been bid for; the current concession contracts will be respected; and the concessionary model will continue to regulate activity in the other regions of the country.

The new state company and the social fund

The administration of the immense richness expected from exploration in the 'Pré-Sal' should be the responsibility of a new state company to be created – PETROSAL – which will be responsible for the management of shared production contracts and the commercialization of oil and gas motivated by the interests of the country.

This company which will be prohibited from operating should have a technical corps of the highest competence, whose basic attributes will be made law and have a reduced number of employees. In the exploration of the richness that belongs to the Union it is understood that it is correct for the Government to manage these resources appropriately, allowing substantial investments, especially in social programs, education, culture, science and technology, environmental development and to combat poverty.

For this reason, we propose creating a new social fund that apart from these fundamental objectives will avoid the problems of countries that from one moment in time to another discover great riches.

We are living through a defining moment of the future we want for Brazil, an instant of affirmation of our nationality, as a free country, sovereign and democratic. In this way, the riches that flow from the exploration of the 'Pré-Sal' will not only contribute to strengthen the economy, but also – and principally – serve to change our social and human base. This treasure, which belongs to all Brazilians, will help Brazil definitively consolidate a position of protagonism in global geopolitics.

We cannot wait any longer! Joaquim Nabuco, a great Brazilian, taught us that “the conquests that arrive late are already cold”. I can say, Mr President, Ladies and Gentlemen, that in no other time in Brazil have there been as many hopes and as much confidence as there are now. That’s why the time is right. We will start a great national debate to decide our destiny. Brazil does not have time to lose. Many thanks."

Petrobras and the Pre-Salt Accumulations

Interview with Petrobras E and P Executive Manager Pre-Salt – José Formigli

Q: Brazil Oil and Gas – What are the major discoveries, hydrocarbon types and reserves?

A: Formigli – The major discoveries in the pre-salt in the Santos Basin are the accumulations named Tupi, Guará and Iara, among others like Jupiter and Iracema. In the Campos Basin section, located in Espirito Santo State, the major pre-salt discoveries were done in the so called "Parque das Baleias", which comprise the Jubarte, Baleia Azul and Cachalote fields, among others.

Regarding the hydrocarbon types, light oil (28º – 30º API) has been found. Some wells found a gas cap (a section of gas above the oil) associated to a heavier oil column. CO_2 has also been found in almost every well, with variable content.

We are not allowed to use the term reserves for the areas in the Santos Basin Cluster. Reserves can only be booked after the commercial disclosure of each area which we intend to do according to the evaluation plan schedule for each area.

Petrobras informed the preliminary estimates of the ultimate potential economical recoverable volumes for Tupi, Iara and Guará, as follows:

Tupi: 5 to 8 billion boe;
Iara: 3 to 4 billion boe;
Guará: 1.1 to 2 billion boe.

Several wells will also be drilled and tested till the completion of the appraisal plan of each block. Besides, the deployment of Extended Well Tests in the main areas, Production Pilots will set the basis for a more accurate recoverable volume estimation.

Q: Brazil Oil and Gas – What is the significance of the pre-salt discoveries?

A: Formigli – The pre-salt discoveries introduce Brazil into a new era within the context of oil-producing nations. First, because the country consolidates itself as one of the largest hydrocarbon exploratory frontiers in the world. Second, because the development of these deposits could place Brazil among the countries that make up the select group of significant net oil exporting nations.

Moreover, the development of the pre-salt areas will also open a broad market for Brazilian companies to supply equipments and materials for the whole upstream chain.

Q: Brazil Oil and Gas – What are the major EP challenges?

A: Formigli – The main challenges are:

Reservoir quality predictability;
Internal reservoir characterization, incorporating the critical heterogeneities found in the pre-salt reservoirs;
Predictability of fluid type distribution along the reservoirs;
Performance of the oil recovery methods. Particularly, the performance of the Water-Alternating-Gas (WAG) injection method for oil recovery, in deepwater, satellite subsea completed wells;
Reduction of well construction duration and, consequently, well costs;
Drilling of deviated wells, ideally extended reach wells, through the thick salt section;
Construction of multi-fractured horizontal wells in order to increase production;
Control of formation damage mechanisms, which means preventing damages in the reservoir;
Temperature management in the subsea flowlines, to prevent wax and hydrates deposition;

Insulated flexible risers, for fluid containing CO_2 and water, in ultra-deep waters;

CO_2 separation, considering compact units, and sequestration, in the producing reservoir or in saline aquifers.

Q: Brazil Oil and Gas – What is the development plan for the pre-salt?

A: Formigli – Petrobras has created an integrated corporate program to coordinate the development of the pre-salt. We're planning on developing the cluster in phases, continuing on a tradition that has been very successful in big enterprises the company has previously undertaken in Campos Basin.

To begin the development of the fields, there are a number of appraisal wells, seismic acquisition and Extended Well Tests (EWTs) that will be carried out along with a Production Pilot in Tupi, in what is being called "Phase 0". This is a phase that will probably last until around 2015 and is focused mainly in information gathering in order to help Petrobras and its partners better understand the characteristics of the pre-salt.

Roughly in parallel comes phase "1a", which is the first phase of the definitive development. This phase starts the implementation of two anticipated pilots (in 2013 and 2014, with potential to be anticipated), followed by another eight "replicant" (quite similar, but not totally standardized) FPSOs (Floating Production Storage and Offloading units) . This phase will employ, mainly, consolidated or rapidly consolidating technologies to achieve a total operated production of 1 million barrels of oil per day in 2017. With this rather aggressive production goal, we intend to provide the company with the cash flow it will need in order to fund the phase "1b".

This 2nd phase of definitive development will be marked by significant production increase and the acceleration of innovation. In phase "1b" we will massively deploy new technologies, specially tailored for pre-salt conditions.

Along with these, there will be a series of logistical support and production export infrastructure projects that will be implemented as needed.

Q: Brazil Oil and Gas – How was the seismic data acquired/interpreted and has the data been largely what was expected in terms of hydrocarbon trapping and migration?

A: Formigli – A very broad seismic acquisition was undertaken at the beginning of the decade. This seismic provided, together with the depositional environment interpretation, the basis for the drilling of the wildcats in the pre-salt cluster.

A high resolution seismic was recently acquired for Tupi which can also be considered the "T0" milestone for future 4D seismic that will be run on that field during its production life.

The other topics are considered proprietary information of Petrobras and may not be disclosed.

Q: Brazil Oil and Gas – In terms of the depositional environment what geological factors will affect recovery?

Pre-salt sediments are composed of a large group of facies, such as microbial boundstones, carbonate banks of grainstones, coquinas, mudstones and mixed facies.

Naturally the reservoir quality distribution will affect the recovery. High permeability layers may also affect recovery, if they extend through long distances.

Q: Brazil Oil and Gas – What Technological challenges such as well construction has Petrobras faced?

A: Formigli – The main challenges are:

• Calibration of the in-house seismic processing algorithms to improve the reservoir imaging, which was the base for the drilling of the wildcats in the different blocks of the Santos Basin Cluster;
• Stabilization of the salt during the drilling phase and also during the long term production;
• Relatively low rate of penetration of wells through the salt section and in the reservoir;
• The Tupi EWT FPSO mooring with torpedo piles in ultra-deep water;
• Subsea tie-back of the EWT well using flexible flowlines in free-cathenary in ultra-deep waters.

It should be noted that none of these topics are currently envisaged as unsurpassable technical barriers.

Q: Brazil Oil and Gas – What are the CENPES PROSAL (the Pre-Salt Technological Program) 23 projects?

A: Formigli – See PROSAL projects, pictured on opposite page.

Q: Brazil Oil and Gas – How will this improve Well Engineering and Reserve and Flow Assurance Engineering?

The main goal of Prosal is to help the company to project the "ideal" well for the pre-salt scenario, considering well cost, well integrity and the high productivity needed in deep water conditions. With respect to reservoir technology, the goal is to reduce uncertainties in reserves estimations, as well as to achieve the maximum recovery efficiency. And with respect to flow assurance, to anticipate solutions for control organic and inorganic precipitates, including modeling of the phenomena, inhibition and remotion (flow?).

Q: Brazil Oil and Gas – How have service companies supported Petrobras in pre-salt EP?

A: Formigli – The service companies are working with Petrobras in several disciplines to overcome the main challenges of the pre-salt projects, such as:

Well construction: new technologies for drilling bottom hole assemblies are being tested and adapted to enhance the rate of penetration, reducing the wells´ duration and hence its cost;
Well logging: new technologies for identification of hydrocarbon reservoirs.

Another important ongoing initiative is the installation of technology centers of the service companies in Brazil, focused on the pre-salt challenges.

Petrobras is also setting up an E&P office in the UK to help coordinate the parties involved (not only service companies, but also universities and other organizations) in the efforts related to technical issues.

Q: Brazil Oil and Gas – What Environmental requirements have been set such as Carbon Dioxide and Prevention of Hydrates?

A: Formigli – In spite of the lack of regulation with regard to CO_2 emissions in oil field development projects in Brazil, Petrobras has decided not to vent the CO_2 produced together with the hydrocarbon in the Santos Basin Pre-salt. CCGS (Carbon Capture and Geological Sequestration) technologies are being considered in the development of the Santos Basin Pre-salt, in order to guarantee that the CO_2 produced associated with the natural gas will not be vented to atmosphere. With regard to prevention of hydrates, the requirements are more related to the technical aspects of flow assurance than environmental.

Q: Brazil Oil and Gas – What Logistical challenges have there been?

A: Formigli – Any operation in the Pre-Salt cluster area represents a logistical challenge in itself, not only due to the complex logistic chain involved in offshore operations, but especially because of the remoteness of the cluster. The long distance between the cluster and the bases (ports and/or airports) from where the personnel and supplies needed for the activities under way are embarked (over 300 km) forces us to manage very long, expensive and complex logistical lines.

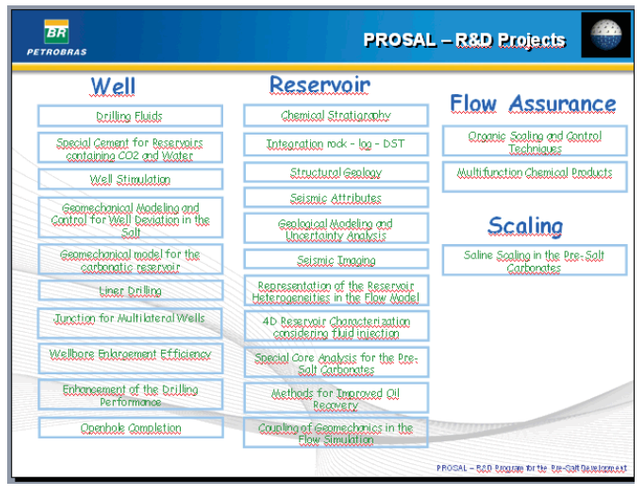
Just to give one simple example, the autonomy of the helicopters that are used to transport the people who are working on board the maritime units in the region has been one subject of concern in the recent past.

Q: Brazil Oil and Gas – What are the Economic Challenges Petrobras faces?

A: Formigli – Many of the challenges that were mentioned here before end up becoming economic challenges. For example, the management and implementation of the long logistic lines needed to supply the cluster will mean higher transportation costs. The same goes for infrastructure that will have to be built to support and handle the production coming from such remote areas.

As far as the production systems themselves, well construction represents almost 50% of the capital expenditures we have to make, so reducing their final price, be it through lowering the costs of goods and services needed to drill and complete these wells or simplifying their projects when possible, is a critical challenge to improve the economics of the development program.

Up to now our continuous effort in improving the overall economics has been quite fruitful and we are very optimistic for the future results of the Pre-salt production development.



Technological Programs: Technology Headed for the Future

By means of its technological programs, CENPES provides Petrobras with technological solutions which constitute the company's competitive differential and ensure it the confidence to be bold and seek ever greater challenges

Reprinted with kind permission from Petrobras Magazine

Carlos Tadeu da Costa Fraga, Executive Manager of CENPES.

Working at Petrobras for the last 28 years, civil and petroleum engineer Carlos Tadeu da Costa Fraga has been at the forefront of technology since he assumed the position of executive manager of the Research and Development Center Leopoldo Américo Miguez de Mello (CENPES), six years ago. In this "talents and ideas factory" he accompanies the advances achieved in the area of current technology programs and keeps track of the awards and patents registered for the innovations developed. Carlos Tadeu spoke in some detail with Petrobras Magazine about CENPES' programs and their contributions.

At Petrobras, the investment in research and development is significant, which makes the company one of those that most invest in R&D globally. How are these resources applied at CENPES?

In conjunction with the business areas of the company, CENPES conducts the activities of the Petrobras Technology System, a group of processes through which global technological tendencies are monitored and which define Petrobras' technology strategies and the principal lines of research which will comprise its technology portfolio. This done, by means of technology programs and research projects, technological solutions are provided to all the areas of the company, in many cases in partnership with suppliers and/or Brazilian or foreign research institutions. In short, CENPES is a major generator and collector of the knowledge which is Petrobras' great competitive differential and ensures it the confidence to be bold and to seek ever greater challenges.

The Deepwater Technology Program, PROCAP, made it possible for Petrobras to explore and produce oil and natural gas at depths of more than 2000m and contributed to the company being awarded, in 1992 and 2001, two OTC prizes, considered "Oscars" in the oil industry, for the development of innovative technologies which benefited the global offshore industry. How is the program doing now? What is the maximum depth at which Petrobras is now operating?

PROCAP, in its 1000m and 2000m versions, made pos-

sible the exploration and production of oil and gas at water depths of more than one thousand and more than two thousand meters, respectively. Now, in the PROCAP 3000 version, the program is already providing us with the knowledge and technology to explore and produce in water depths of 3,000 meters. We have already explored accumulations at more than 2,500 meters in the Gulf of Mexico and also in the Campos Basin, where, for example, we have drilled an exploratory well 1-RJS-567, in block BC-100, at a depth of 2,853m. Shortly, another of our wells will start production at 2,500m in the Gulf of Mexico. But for the time being the greatest depth at which we have produced oil is 1,886m, in the Roncador field, Campos Basin. Now that this technology is mastered, our target is to develop ways to explore and produce oil and gas in ultra-deep waters, that is, at a depth of more than 3,000m.

Much of the pioneering spirit which made Petrobras renowned abroad is due to PROCAP, isn't it?

Without doubt, thanks to PROCAP, Petrobras was the first company in the world to anchor platforms in deep water. With the help of robotics, it installed the first Wet Christmas Tree, which is a set of valves that, on the seabed, controls the pressure and flow of a subsea well, diverless, that is to say, without a diver, at depths where humans cannot operate. The company was a pioneer in the use of flexible risers, which are pipelines for the outflow of oil and/or gas that connect the wells to the platforms. In addition, the company was the first to use rigid risers in association with semi-submersible platforms in deep water. Thanks to these innovations in the area of PROCAP, in December 2008, just in Brazil, Petrobras operated 728 subsea wells, had 112 offshore production systems, and produced approximately 1,893,000 barrels of oil equivalent per day from offshore fields, of a total of 2,340,000 boed. These numbers place the company as the largest deepwater operator in the world, responsible for practically 25% of the global production in this area.

At the moment, all eyes are on PROSAL, the Pre-Salt Technology Program, created only a year ago. What is being done within this program?

The pre-salt province has presented technological challenges in practically all areas, including the drilling of wells through thick salt layers in ultra-deep waters. But in this first year of development of the work within the program, we have found that our prior experience has been a great advantage. Because of this, the first results are beginning to materialize. Through extended well tests, the first well in the Espirito Santos pre-salt province, the ESS-103A (in the Jubarte field) is already producing, and, in the first week in May of this year, the first well of the province in the Santos Basin went into production. In addition, we are implanting the pilot project of the Santos Basin pre-salt province, which will come onstream in 2010. The conception of the first phase development of the Santos Basin province has also been defined and the installation of two pilot FPSOs initially and then eight definitive FPSOs is foreseen. As Petrobras did successfully in previous

Petrobras has the know-how to explore for and produce oil and gas at 3,000m of water depth

undertakings in the Campos Basin, the development in phases will make possible the collection of data and the testing of technological innovations, which will be implemented in subsequent phases. In short, we are achieving important advances on multiple fronts.

Speaking of the pre-salt province, there is another technology program under development connected to this new exploratory frontier, the ProCO_2. What does this program consist of?

Within this program, efficient methods for the capture and storage of CO_2 will be developed and the possibility of injecting CO_2 back into the reservoirs will be analyzed as a mechanism for the additional recovery of oil.

What is being studied and done in the area of PROFEX, the Technology Program in Exploratory Frontiers?

The purpose of PROFEX is to develop and integrate knowledge and technology, which, in the medium and long terms, can contribute to the discovery of oil provinces in new exploratory frontiers and to the capacity enablement of Petrobras with respect to the exploration of natural accumulations of gas hydrates. Within the scope of this project, we are studying the Solimões Basin, a Paleozoic land formation and the continental margin of South America. We are also analyzing how to extract and make commercially viable the gas from natural gas hydrates, solid compounds comprising water and gases like methane and carbon dioxide, abundant in marine sediments and existing in the form of crystals in the continental margins. Nobody in the world is presently doing this on a commercial scale. Heavyweight partners such as the University of Tokyo, the Geophysical Observatory of Trieste, and the Rio de Janeiro Catholic University will assist us in our work.

How is the Basin Modeling Technology Program, PROMOB, progressing?

Within the scope of this program, we have developed the software prototypes SimBR and Steno, which have enormously facilitated Petrobras' work. SimBR simulates geological processes of the development of oil systems, such as the depositing and erosion of sediments, rock compacting and the alteration in porosity, and the generation, migration, and accumulation of oil. Steno is software for stratographic modeling and simulates sedimentary conditions in basins over geological time and can assist us in foreseeing the occurrence of reservoir rocks, which may contain petroleum, in new well locations. In addition, we have integrated our data bases and created a corporate data bank for consultation by Petrobras' areas and units in Brazil and abroad.

In the area of the Advanced Oil Recovery Technology Program (PRAVAP), the technological branch of the E&P area's Mature Fields Recovery Enhancement Program (RECAGE), the results have been promising, haven't they?

Yes. Globally, the oil recovery factor in mature fields, that is, fields that have reached their production peak and have gone into decline, is, on average, 35%. Thanks to PRAVAP, we have achieved a recovery factor of 50%, for example, in the Marlim field, which has been producing for 20 years. And there have been cases of recovered fields which have reached a second peak higher than the first one. Thanks to the program, mature fields such as Carmópolis, Canto do Amaro, Bonito, and Albacora have

José Caldas / Petrobras Image Bank

The Solimões Basin

regained a new vigor. Various techniques have been employed to rejuvenate our fields, including, for example, the injection of water, carbon dioxide (CO_2), or steam into the wells, the alternate injection of water and gas, the subsea injection of sea water, and the use of chemical products. The program is of extreme importance to Petrobras because the majority of the company's fields are mature. It has also generated cost optimization, increased production, and an increase in our reserves.

The Heavy Oil Technology Program, PROPES, ended in 2008 with excellent results, according to CENPES evaluation. What did Petrobras learn from this program?

Created in 2002, PROPES, which permitted the course of oil from exploration to refining, contributed decisively to the production viability of heavy oils in an offshore environment. With this, the company achieved record production of viscous heavy oil at sea, a total of about one million barrels. The pilot project implemented in the Siri reserve, located in the Badejo field in the Campos Basin, made possible the large scale production at sea of extra-heavy, high viscosity oil of 12.3° API. Within the scope of the program, technologies such as the long extension horizontal drilling of wells with sand control, systems of centrifugal pumping for the artificial elevation of oil, platforms equipped to make possible the processing of large liquid flows, and the use of mobile production platforms enabling Long Duration Tests in heavy oil fields were consolidated. More specifically, in the oil processing area, new technologies were developed to separate water from oil. With respect to the advanced recovery of heavy oil, in turn, a project was developed to inject viscosified water into a well in the Papa-Terra field. Regarding the reduction of viscosity in extra heavy oil, a project was implemented in the Tambuatá field in the Santos Basin.

Speaking of heavy oil, CENPES has a program focused on the processing of heavy and extra-heavy oils, the Refining Technology Program, PROTER. How is that going?

In the Supply area, one of the biggest challenges facing Petrobras is to equip its refining facilities to increase the production of diesel with a reduced environmental impact, using heavy oil. Also being sought is a solution for increasing the hydrotreatment capacity (HDT) of the Petrobras System refineries to satisfy the market demand for increasingly cleaner fuels. In the case of processing heavy oil, after the initial process of distillation, half of the volume still remains in the form of atmospheric residues (RAT), which needs additional processing for conversion into light, valuable fractions of oil, such as diesel oil and gasoline. This happens within the scope of PROTER, which comprises projects aimed at the development of innovative technologies for the conversion of heavy oil fractions into fuels and petrochemical products in Fluid

Catalytic Cracking and Delayed Coking plants. These technologies are of great significance in the current refining scheme. In the Abreu e Lima Refinery, for example, a process will be implemented for the coking of RAT which will increase the production of diesel oil by 28% compared to a traditional coking plant. In the RLAM, RECAP, and REFAB refineries, in turn, it is already possible to process RAT in the Fluid Catalytic Cracking Units and increase the production of diesel components by 10%. In COMPERJ, the FCC Petrochemical technology will be implemented to increase the production of ethylene and, principally, propylene. Finally, in order to produce gasoline with low sulfur content, in addition to acquiring AXENS technology, we will install our own technology in the new HDT unit of RECAP, which should go into operation at the end of 2010.

Still in the refining area, the Optimization and Trust Technology Program, PROREC, is in place. What results are being achieved under this program?

Within this program, one of the major challenges to be faced is naphthenic corrosion of metal materials, that is, corrosion by naphtha, an oil subproduct which is measured by the Total Acidity Index, TAI, and which increases according to acidity in oil and oil products. Thanks to PROREC, it became possible to identify the usage limits of various metallic materials with which we work, to inform the Petrobras System refineries of the maximum degree of oil and oil product acidity which can be safely processed, and to process oil with significant levels of acidity. We implemented projects of metallurgical adequacy in refinery distillation units, in such a way as to prolong the useful life of the equipment, and now we have carried out tests with naphthenic corrosion inhibitors to optimize these processes. In addition, we have evaluated the variables which influence the integrity of the equipment and the risks of structural failure as a result of time in use, and we have optimized inspections and maintenance and therefore prolonged the useful life of the equipment. The knowledge acquired up to now has permitted us to refine the technical specifications in the purchasing of equipment and to optimize the manufacture and costs of this equipment.

With respect to natural gas, what have been the contributions of the Natural Gas Technology Program, the PROGAS, to Petrobras?

The challenges of the program have been how to make the gas logistics network in Brazil flexible and to develop solutions for gas transportation, in a competitive and flexible way, from locations distant from the Brazilian coastline to the consumer markets. To reach these goals, we are acting on three fronts. With the coming onstream of the fields existing in the pre-salt province, we are studying, as an alternative to the outflow of the natural gas obtained, transportation in the form of liquefied natural gas in ships. The natural gas would be converted into liquid, with its volume reduced around 600 times, and transported in vessels to a regasification terminal installed on land, where the processed cargo would be transformed into gas once again. To achieve this, it is necessary to develop deepwater gas liquefaction plants. We will define the floating LNG unit in the second half of 2009. Another alternative being studied is compressed natural gas

Petrobras has achieved a production record for viscous heavy oil offshore

for embarkation. The natural gas would be compressed to 250kgf/cm², it would be stored in cylinders placed on board CNG vessels, and these ships would transport the fuel to a gas pipeline network, through which the gas would flow to processing units on land. This technology will be available to Petrobras by the end of 2009. Finally, we are also studying the gas-to-liquid, or GTL, technology, which is the chemical transformation of natural gas into high quality derivatives with high added value and low environmental impact. Its use in an offshore environment is still in the embryonic stage, but we are developing a pilot plant, for installation in a production vessel, so as to evaluate the technology on a larger scale. The plant will begin operations in 2010 in the state of Sergipe.

Speaking of ships, pipelines, and outflows, the Transportation Technology Program, PROTRAN, is also part of the CENPES technological program portfolio. How is this program doing?

We have implemented research projects related to ships and pipeline networks and invested in infrastructure designed to provide operational excellence in various modes of transportation. In our efforts, we have had as partners Brazilian universities and the Petrobras Pipeline Technology Center, CTDUT, where we test and validate technologies and equipment. For example, we have researched materials which reduce the corrosion in tanks, ships, and pipelines, the minimization of contamination problems which alter the quality of the products during transportation, and ground movement, so that we can be prepared in advance before damage to the integrity of the pipelines occurs; we have validated sensors and equipment responsible for security in pipeline rights-of-way and tanks; and we have implemented repair methods which enable the re-establishment of operations safely and quickly.

What is new in regard to the Renewable Energy Technology Program, PROGER, now focused, in the short and medium terms, on biofuels?

We have developed technology, patented by Petrobras, to produce biodiesel with low cost raw materials abundant in Brazil and with high oil content in seeds from plants such as palm, Barbados nut, the African oil palm, sunflowers, and the castor oil plant, different from what is common in the world where soybeans and rapeseed are more used. We are able to produce biodiesel of international quality with 30% of castor oil in the blend. Also, we have finished the project for a biodiesel plant with 100% Brazilian technology. The adaptation of existing plants is being studied by our specialists. Studies are also in progress to make viable the creation of farms to cultivate algae for the production of biodiesel with the oil extracted from these plants. Regarding the diesel produced using the H-Bio process, that is, using the technology patented by Petrobras which makes possible the processing of vegetable oil mixed with diesel oil fractions, we already have six Petrobras refineries adapted to produce it once it is considered commercially advantageous. With respect to ethanol, in the first half of 2009, we finished the design for a demonstration plant for ethanol from lignocellulose, produced from vegetable residues such as sugarcane bagasse and straw. The plant will begin operations in 2010 or 2011.The projected production is about ten thousand liters of ethanol per day.

Has the Biofuels Innovation Technology Program, INOVA, sparked the introduction of many innovations in the market?

In this program, we are constantly seeking to develop differentiated products with improved performance and new components, produced with new routines and with reduced greenhouse gas emissions. Some of the products developed include Brazilian Podium gasoline; Podium for the Argentine market; Diesel Podium for pickups, with advanced formula and additives; Diesel Verana for the nautical segment; and 22 different gasoline formulas for Formula 1, always seeking a constantly improved performance. At present we are working to develop an aviation biokerosene and a lead-free aviation gasoline.

CENPES also has environment technology programs. For example, how is the Environment Technology Program, PROAMB, doing?

The challenges of the program are to develop technologies which minimize the impact of Petrobras activities on water systems and resources. To achieve this objective, we are working to reduce the residues generated in our processes, by sustainable action in sensitive ecosystems and by the sustainable use of water resources. To minimize the residues generated, we are testing, on a pilot scale, the heat treatment of residues, which will make possible the processing of oily sediments, previously a cause of environmental damage, so as to obtain good quality oil. Preoperational tests will begin this year on a pilot bioreactor for the treatment of soil, recuperating soil contaminated by oil and/or oil products and making possible its reuse. In sensitive ecosystems, more specifically in the Amazon, we will implement projects such as EcoUrucu, with the objective of improving the sustainability of the oil and gas production processes in the Urucu gas and oil province; the Piatam, which will carry out the socio-environmental monitoring of the Petrobras oil and oil products

Petrobras is adapting its refining park to increase the production of diesel

transportation routes; and the Cognitus Project, in which we are developing robots to collect environmental data. As to the reuse of effluents, in collaboration with the Supply area, we have implemented technologies with this objective in the REVAP, REPAR and RECAP refineries, in the LUBNOR lubricant factory, and in CENPES, at the same time that conceptual designs have already been created for implementation in the Rio de Janeiro Petrochemical Complex. Water reuse using diverse electrolysis technologies is being validated in the REGAP refinery. Already, the reuse of water produced in the exploration and production processes is being adopted for the recovery of oil in the Petrobras units in the states of Ceará, Sergipe, and Rio Grande do Norte. Finally, we are developing technology to take advantage of the water produced together with petroleum for use in the irrigation of oleaginous plants which will serve as raw materials for the production of biodiesel in Ceará and for the cogeneration of electric energy in the Termoaçu thermoelectric plant in Rio Grande do Norte.

How is the Climate Change Mitigation Technology Program, PROCLIMA, doing?

The program, created in 2007, has four focal points - carbon capture, energy efficiency, the evaluation of the environmental performance of fossil and renewable fuels during their life cycles, and the development of technologies and models for the evaluation of the impact of climate change on Petrobras' business affairs. Of those programs implemented, it is worth highlighting, in the field of carbon capture, that we have begun injecting CO_2 in the Rio Pojuca aquifer in the Recôncavo Baiano with the goal of injecting a total of 50 tons per year in that location. This is the first project for the geological capture of carbon dioxide in operation in South America. Other projects are still under study or are in their initial stages.

From what has been seen, the entrepreneurial spirit is prevalent in all of CENPES' technology programs.

That's true. The capacity to implement new technological solutions is the great differential of Petrobras and of CENPES, which provides technological solutions for the company by means of technology programs and research projects. Technological success depends fundamentally on certain factors. First, there needs to be alignment between the requirements of the final user and the system focus. In the second place, it is necessary to integrate all those who can contribute to the desired innovations, including suppliers and academics. In the third place, the effort for implementation must be unrelenting. Good ideas, if they are not implemented, are no more than that. Innovation will only take place when it is implemented industrially. Petrobras is fully aware of these factors and encourages us to take entrepreneurial actions. It's in our DNA.

A Boost for Development

Platforms P-51 and P-53 contribute to the revitalisation of the Brazilian shipbuilding industry and to the creation of jobs and income in Brazil, ensuring increased oil and gas production and development of the nation.

Domingos Tadeu / Petrobras Image Bank

The President of Brazil (center) participated in the launching of the FPSO P-53

Platforms P-51 and P-53 contribute to the revitalization of the Brazilian shipbuilding industry and to the creation of jobs and income in Brazil, ensuring increased oil and gas production and development in the nation.

Two Petrobras platforms, the FPSO P-53 and the semi-submersible unit P-51, constructed in Brazil and which went into operation in late 2008 and early 2009, respectively, have already had a significant impact on the

country prior to the start of production and are of great promise for the coming years. They have contributed to the revitalization of the national shipbuilding industry and to the creation of domestic employment and income, given that more than 70% of the goods and services were acquired from Brazilian suppliers. In addition, the platforms will reinforce the country's self sufficiency in oil, as they will contribute an extra daily production of 360,000 barrels of oil and gas.

P-53

Resulting from the conversion of the Portuguese vessel Setebello, the FPSO-53, constructed in Brazil, constitutes an important element of the Brazilian government's Plano de Aceleração do Crescimento – PAC (Growth Acceleration Plan) and has provided an important boost to the Brazilian shipbuilding industry. After all, as the Petrobras director of Exploration and Production, Guilherme Estrella, emphasizes, the project has generated around 4,500 thousand direct and 15,000 indirect jobs.

In the energy field, the contribution will also be considerable. "The FPSO will have a production capacity of 180,000 barrels of 20º API oil per day, will compress six million m³ of gas and will generate 92 MW of electric energy. Regarding water injection capacity, the unit's capacity will total 245,000 barrels daily," says José Antonio Figueiredo, the Petrobras South-Southeast Exploration and Production division executive manager.

The FPSO will be installed in the Marlim Leste field in the Campos Basin, 120 km from the coast, and will be anchored at a depth of 1,080 meters, becoming the first production unit in that field. There, it will be interconnected to 21 wells, of which 13 will be oil and gas producers and eight, water injectors.

Equipped with a 26 cm diameter turret system, that is, a receiving tower for flexible production and injecting lines, oil ducts, gas ducts, and anchorage lines, it will also have the capacity to receive 75 flexible lines.

Oil production will be transported to land by means of

André Valentim / Petrobras Image Bank

The FPSO P-53.

Petrobras Image Bank

Autonomous re-pumping platform PRA-1.

an autonomous repumping platform, the PRA-1. Part of the daily gas production will be used for the unit's internal consumption, as a fuel for the generation of electric energy. The rest will be transferred to platform P-26, to be incorporated into the Campos Basin gas network.

P-51

Destined to operate in the Marlim Sul field in the Campos Basin (RJ), 150 km from the coast in a stretch of water 1,255 meters deep, the P-51 is the first semi-submersible platform constructed entirely in Brazil. It is also another result of the policy implemented by the Brazilian government and Petrobras to revitalize the national shipbuilding industry.

In this regard, the unit was a key component in the Plan for Accelerated Growth currently in force in Brazil. "The work on this project alone created 4,000 direct and 12,000 indirect jobs, which helped strengthen the growth of Brazilian industry and the consolidation of the national content policy in Brazil," explains Guilherme Estrella, the Petrobras director of Exploration and Production.

Paulo Arthur / Petrobras Image Bank

Semisubmersible platform P-51.

Included in the Campos Basin Drainage and Treatment Director Plan (PDET) and in the Plan to Anticipate Natural Gas Production l (Plangas), the P-5 will also contribute to increasing the supply of gas in the Brazilian market.

The platform will have a production capacity of 180,000 barrels of 22º API oil per day, a gas compression capacity of six million cubic meters, a water injection capacity of 282 bpd, and a generation capacity of 100 MW of electric energy daily, a total sufficient to supply a city of 300,000 inhabitants. In addition, it will be interconnected with 19 wells, of which 10 will be producers of oil and gas and 9, water injectors, and will be responsible for about 8% of the total volume of oil produced in Brazil, once the production peak is reached, foreseen for 2010.

Considering the contribution which the P-53 and P-51 platforms have made to the revitalization of the Brazilian shipbuilding industry and the important role reserved for both in the strengthening of Brazil's self-sufficiency in oil, Petrobras and Brazil have won important victories, as well as greater facility in developing risk ventures in the future.

The Super Giant Pre-Salt Hydrocarbon Province in the Deep Water Santos Basin, Brazil

By Márcio R. Mello, Nilo C. Azambuja, Eduardo de Mio, André A. Bender, Carlos Luciano. C. de Jesus and Priscila Schmitt – HRT Petroleum

ABSTRACT

Recently, HRT, in cooperation with CGGVeritas, finished a very important study over Brazil's pre-salt giant oil province: the 3D Petroleum Systems Modeling of the Deep Water Santos area, covering the BM-S-8, BM-S-9, BM-S-10 and BM-S-11 Cluster Blocks and surroundings (Fig. 1). This area encompasses the five most important, recent worldwide discoveries including the supergiant fields of Tupi, Jupiter and Iara and the successfully tested prospects of Bem-te-Vi, Guará, Carioca and Parati. Volumes are surprisingly large, which may reach 18 Bbbls of reserves. This summary article includes a partial view of a very detailed petroleum system 3D model of the Cluster area, deep water Santos Basin, in which oil and gas generation, expulsion and migration pathways are showed as well as the impressive prediction of hydrocarbon volumes and composition of the oil and gas accumulations.

METHODOLOGY

A 3D integrated petroleum system modeling using a geological and geophysical framework was built based on very detailed mapping using a 20,000 km^2 PSDM seismic data (provided by CGGVeritas). The 3D basin

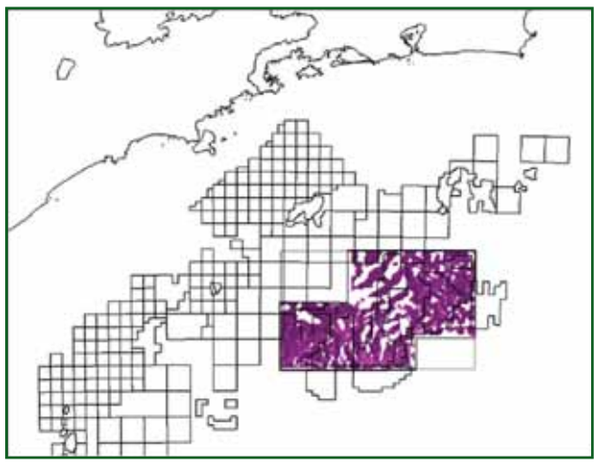


Figure 1 - Location of the study area in deep water Santos Basin. This area contains the Tupi oilfield announced as having up to 8 BBbls of oil reserves.

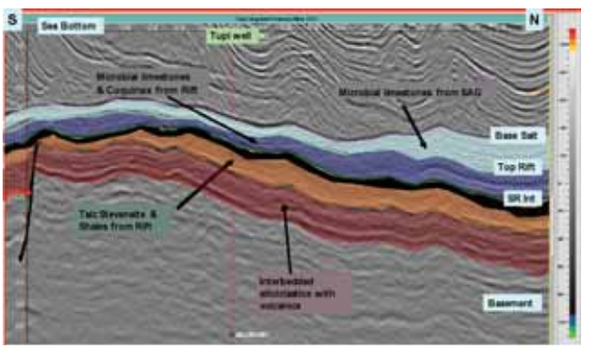


Figure 2 - North-south geological section across the study area showing the main pre-salt sedimentary facies mapped in the area of the Tupi well. Note the distribution of the main carbonate reservoirs and their association with the source rock sequences (HRT-CGGVeritas).

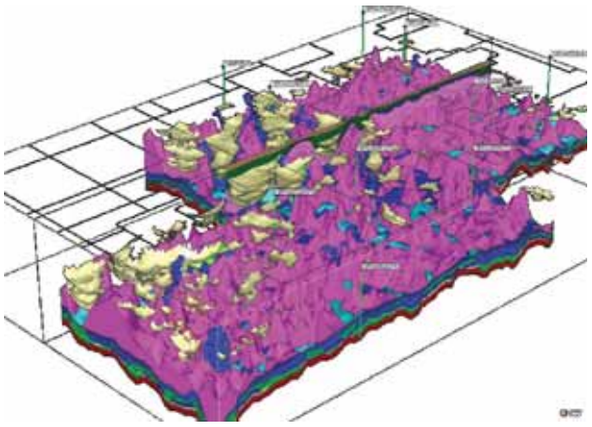


Figure 3 - Detailed facies distribution in Sag and pre-salt section built using Petromod software and based on well data, conceptual geological model and seismic attributes. The view presents the salt layers (in pink), the carbonate reservoirs in the upper part of Alagoas SAG sequence, the source rocks and the basement.

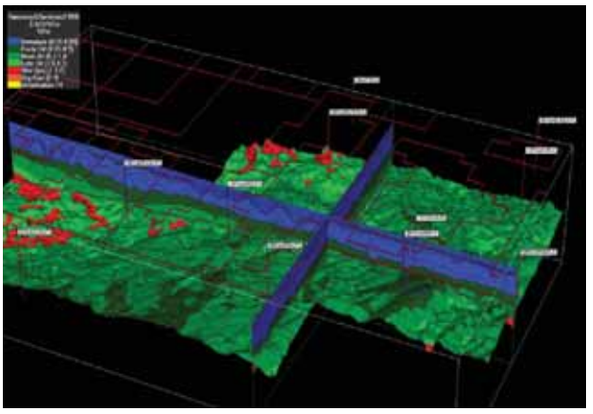


Figure 4 - Vitrinite data prediction over the studied area suggesting an oil prone condition for the whole pre-salt area in deep Santos Basin. Present time conditions.

model used information about source rocks richness, thickness, distribution, kerogen kinetics, reservoirs quality, sealing rocks and trap geometries. An integrated 3D petroleum system simulation with PetroMod (provided by IES) allowed an evaluation of the interplay among the elements and processes of the petroleum system to assess source rock potential (vertical and horizontal distribution), thermal evolution of the source rocks, transformation ratio, hydrocarbon generation and charge, timing of migration, oil origin, quality, and a volumetric quantification of the accumulated petroleum in the main reservoirs (Fig. 2). A detailed facies model from pre-salt section was built based on well data and conceptual models from seismic interpretation associated with previous knowledge of the tectono-sedimentary sequences of the Santos basin (Fig. 3).

RESULTS

The Santos Basin is considered today the most important frontier of exploration in Brazil to hold giant to super giant hydrocarbon reserves in the pre-salt sedimentary sequences (Melo. *et al.*, 2009).

The main results of the 3D Petroleum system modeling of the Cluster area of the Santos basin indicate that transformation of the main depocenters of the Barremian source rock systems in the area reached almost 80%

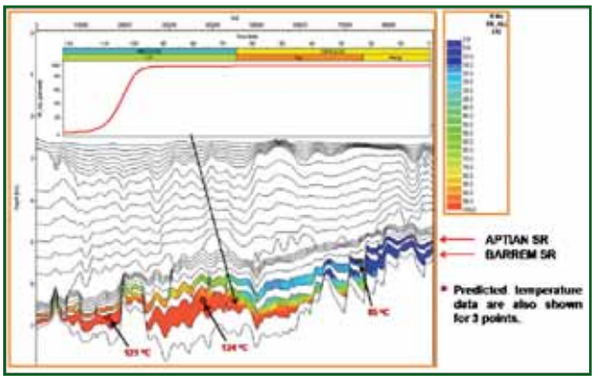


Figure 5 - Transformation ratio values in a cross section through the Tupi High. Note the low temperature values in rift section.

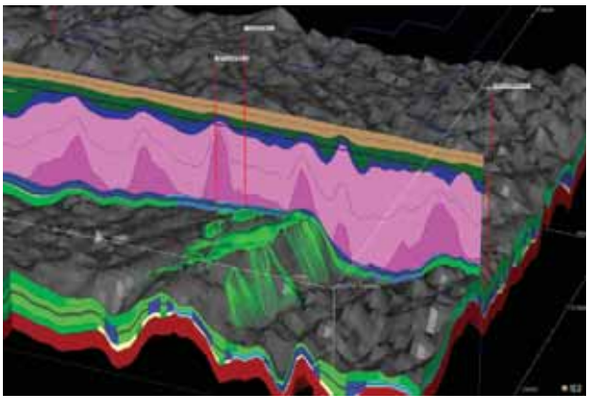


Figure 6 - Accumulated hydrocarbons in the Tupi Area. Announced reserves can reach up to 18 Bbbls of oil reserves.

at present day. On the other hand, the Aptian lacustrine source rock is partly transformed in the depocenters (70% in average) and it is not expelling in the highs (<20%) where the main accumulations were discovered up to today (Mello *et al.*, 2009). The predicted vitrinite reflectance data suggested that most of the Aptian source rock systems, deposited in a lacustrine brackish to saline alkaline lake environment, are inside the early to peak oil generation stage in the mapped area (Fig 4).

Two physical parameters are mainly responsible for the adequate thermal conditions for the oil generation and its preservation: the heat flow history and the high average thermal conductivity of the evaporitic layers. Contrary to the prediction of high heat flow values in ultra deep waters by theoretical models (e.g. McKenzie type of models), the heat flow peak never reached values higher than 120 mW/m^2. Additionally, the vulcanoclastics that occur stratified in the pre-salt sequences so far do not represent a risk neither in terms of high temperature intrusion nor for reservoir or source rock quality (Mello *et al.*, 2009).

Predicted temperature values in the main source rock systems deposited in a lacustrine saline alkaline lake environment, such as the Aptian calcareous black shale, section (e.g. Coquinas section in the Campos Basin; Mitsuro, 2008) and the Barremian black shales, deposited in a lacustrine brackish alkaline lake system (e.g. Talk Stevensite section in the Campos Basin; Mello *et al.*, 1995 and 2009; Dias, 2004) range from 92° to 130°C in the deepest part of the basin, and 70° to 90°C in the shallowest areas (Fig. 5). Such values are critical in, not only preserving the oil prone nature of the whole area, but also preserving the permoporosity and reservoirs temperatures (Mello *et al.*, 2009).

In general the pressure behavior seems to reflect the structural discontinuity of the halite salt core of the evaporitic sequence, which allowed pressure release in the pre-salt layers reaching this way normal pressure values for most of the area. Excess pressure is surprisingly low in the pre-salt rocks. The highest excess pressure values are less than 0.2 MPa in local depocenters and are at hydrostatic state over most of the area (Mello *et al.*, 2009.

However, it is important to mention that the main exploration and production risk lies in the nature and petrophysical characteristics of the reservoir rocks, composed by stromatolites, coquinas and volcanoclastics

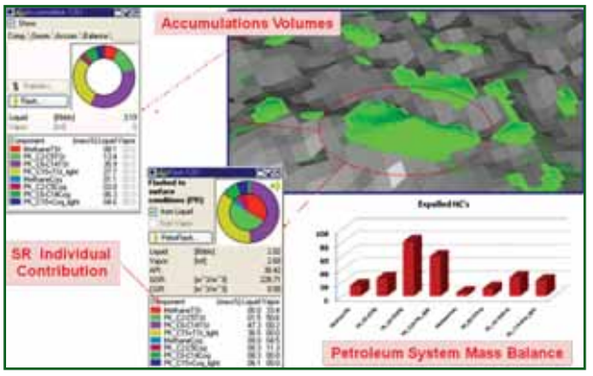


Figure 7 - 3D petroleum system accumulation simulation model, only for the pre-salt province, suggests a potential reserve, in the Cluster area of the Santos Basin, much larger than reported, in excess of 60 Billion bbls of oil reserves.

that occur alternating themselves and sum more than 400 m in thickness and extend for more than 1500 km, from Southern Santos up to Northern Espírito Santo Basin, presenting porosities ranging from 8% to 20% and permeability ranging from 20MD to 500MD (Mello *et al.*, 2009).

The charge and accumulation simulation model, only for the pre-salt province, suggest a potential reserve, in the Cluster area of the Santos Basin, much larger than reported, getting numbers over to 60 Billion bbls of oil reserves (Figs 6 and 7).

The discoveries of low sulfur, pre-salt, lacustrine origin light oil (31° to 37° API), occurred in carbonate reservoirs called stromatolites and coquinas. The petrophysics of such reservoirs are unique and made possible to preserve permoporosity in very deep conditions (over 5,000 meters).

The supergiant accumulations of light oil, condensate and gas found in the study area, involving the Tupi, Carioca, Parati, Guara, Iara, Bem-Te-Vi and Jupiter are trapped below a huge evaporitic sequence that was able to hold significant hydrocarbon column heights, becoming a key success factor in establishing one of the most prolific petroleum systems of the world: The Great Lagoa Feia Petroleum System (Mello, *et al.*, 1995 and 2009).

It is important to mention that all volumetric estimations are based on premises that consider the same permoporosity distributions for all the stromatolites, coquinas and clastic basal reservoirs.

ACKNOWLEDGEMENTS

The authors would like to thank CCG-VERITAS who provided the whole 3D Seismic Data for the 3D Petroleum System and Exploration Risk Assessment Multiclient study performed by HRT & Petroleum in association with CGGVeritas. The authors also thank gratefully the geophysicists Alexandre Coelho and Paula Kale Brazão and all the HRT personnel who worked together in this project. We also thank IES that provided the PetroMod 3D for the simulations.

REFERENCES

DIAS, J.L. 2004. Tectonic, stratigraphy and sedimentation during the Aptian along the Brazilian eastern margin. B. Geoci. Petrobras, Rio de Janeiro, v. 13, n. 1, p. 7-25, nov. 2004/maio.

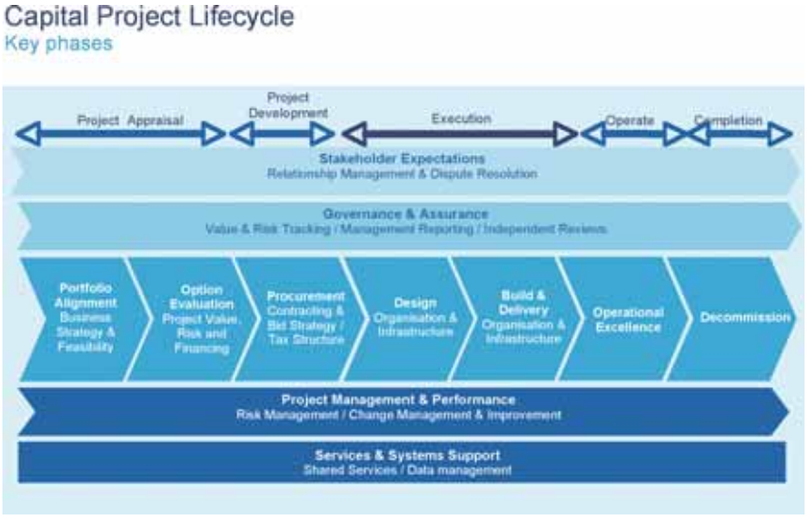
MELLO, M. R., TELNAES, N. J. R. MAXWELL. 1995. The hydrocarbon source potential in the Brazilian Marginal Basins: a geochemical and Paleoenvironmental Assessment, in A. Y. Huc, ed., paleogeography, paleoclimate and source rocks: AAPG Studies in Geology, v. 40: Tulsa, AAPG, p. 233-272.

MELLO, M. R., AZAMBUJA FILHO, N.C., BENDER, A., BRUNO. P.S., DE MIO, E., CATTO, A. J., SCHMIT, P., JESUS, C.L. 2009. The super-Giant Discoveries in the Pre-salt Hydrocarbon Province of Santos Basin. Submitted to AAPG bulletin.

MITSURU A. 2008. New Paleogeographic Reconstruction for the South Atlantic Aptian: Its Implication for Petroleum Exploration in Brazil, 2008 AAPG International Conference and Exhibition, October 26-29, 2008, Cape Town, South Africa – Abstracts, #90082.

Brazil – the Big Bet

By Mauricio Girardello



Brazil is definitely making its presence felt and consolidating its position in the current climate of post-crisis recovery. Obviously, the crisis was not a good thing for anyone, but, from another point of view, it helped Brazil gain more visibility on the international scene. Ranking eighth in the world's economies, according to World Bank data, the country has weathered the last months in relative calm, outside the epicenter of the crisis that has ravaged developed and developing countries alike since the crash of Lehman Brothers Bank in September 2008. In the last few years, Brazil has been consolidating itself as a preferred destination for the allocation of international funds, which surpassed U$18 billion in 2006 and U$45 billion in 2008, with growth expected again this year.

Current and future investment opportunities corroborate and support this: oil exploration in the pre-salt layer, the Growth Acceleration Plan ("Plano de Aceleração do Crescimento – PAC"), the World Cup in 2014 and the Olympic Games in 2016 – all world events that will see at least a decade of heavy investments in capital and infrastructure projects all over the country. New projects are being instigated almost daily in order to meet all present and future needs.

Enterprises in energy, transport and logistics, sanitation, mining, urban mobility, telecommunications and industry are being launched in the media, backed up with impressive figures.

In the "Oil & Gas" industry, Petrobras investment plan (approximately U$180 billion from 2008 to 2013), from orders for drilling platforms and oil tanks to dockyards and new projects for refineries and ducts, all typify the investment being made. The knock-on effect from these enterprises permeates the entire industry chain, impacting on hundreds of national and international companies.

While these projects represent a huge opportunity to develop and expand the economy, they consequently bring associated risks and a significant need for qualified labour, as well as changes in technological models and in management structures.

It is essential that companies in the sector know and implement management methodologies suitable to this new scenario, aiming for a balance between investments and risks. Monitoring of a project throughout its lifecycle is fundamental and must focus the structuring processes, and technical and management analysis. Each project, from the original concept to completion by way of definition, structuring and planning, must be accompanied by a systematic evaluation of continuity options based on studies done at each stage.

Throughout, good practice demands an organizational structure that ensures adequate governance of the project, at the same time dealing with the increasingly urgent question of sustainability inherent in the implementation and operation of the enterprise.

To conclude, it is fundamental that companies in the sector also consider portfolio management, aiming strategically to handle the investment portfolio while taking into consideration adequate returns, capital costs, structured risk mapping and alignment with industry tendencies and with the company's global strategy, thus maximizing the results and benefits for the shareholders.

Mauricio Girardello is the lead partner of PricewaterhouseCoopers Brazil for Capital Projects and Infrastructure services.

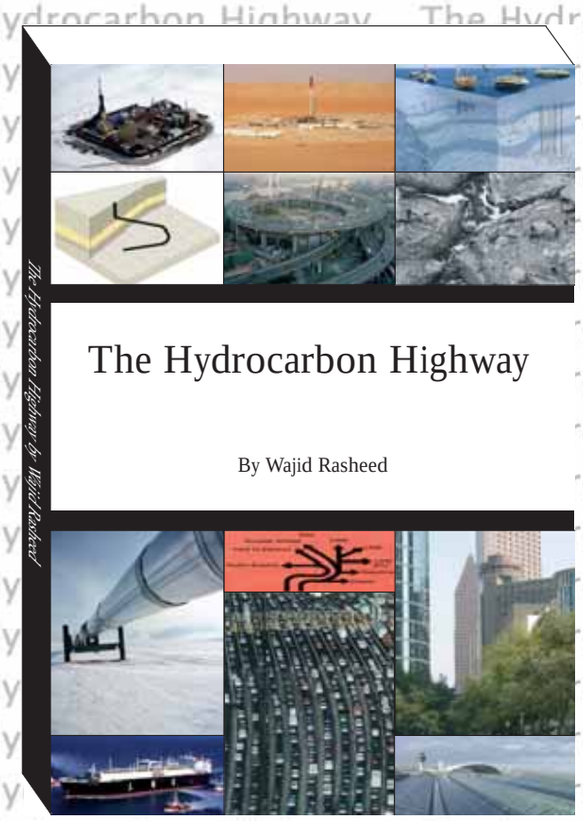
EPRASHEED
signature series

Purchase Now

The Hydrocarbon Highway

"I found the book excellent because it provides a balanced and realistic view of the oil industry and oil as an important source of energy for the world"

Dr AbdulAziz Al Majed, the Director of the Centre for Petroleum and Minerals at the Research Institute at King Fahd University of Petroleum and Minerals



Please send me ☐ copies of The Hydrocarbon Highway

Name: .....

Title: .....

Company: .....

Mailing Address .....

.....

.....

Phone: Fax: .....

Please debit my credit card:

Visa/Mastercard Number .....

Name on Card..... Expiry.....

☐ I enclose a cheque or banker's order in US Dollars, payable to EPRasheed Ltd

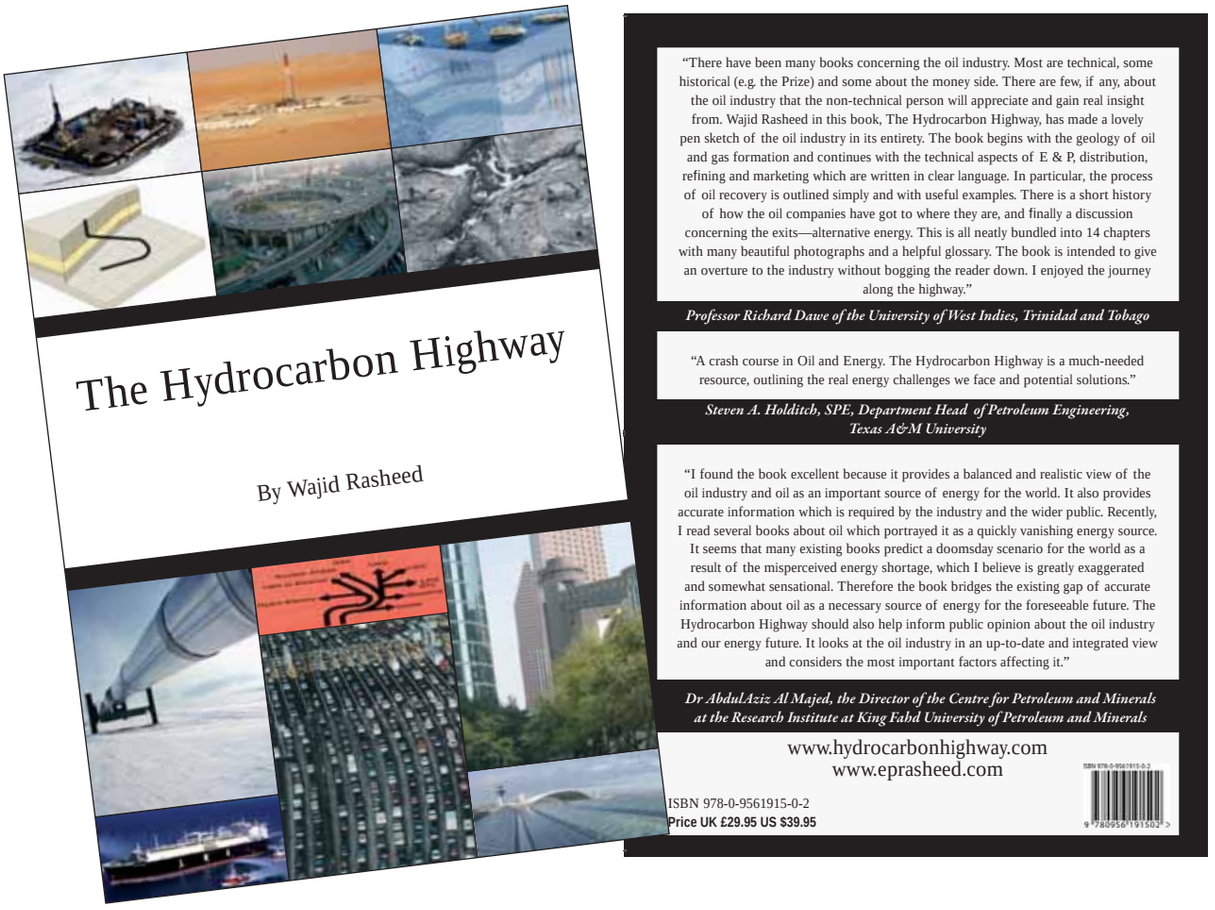
Charges Per Book:
The Hydrocarbon Highway: $39.95
Standard Delivery: $10.00 ☐ Express Delivery $30.00 ☐

Signature .....

Mail all Orders to:
68 Montague Road, Slough, Berkshire, SL1 3RW, England, UK

The Fall of the Oil Curtain

A chapter from The Hydrocarbon Highway, by Wajid Rasheed



What would a sketch of the global landscape of reserves and production look like? No doubt, its most salient features would be the growing appetite for oil and gas and the drive for reserves replacement from frontiers and mature fields. In the background would lie the cycles of 'feast or famine' and the long lead times that govern investment and returns. Yet, tantalizingly hidden away is the essence of the industry – petroleum reserves.

The Oil Curtain neatly symbolises resource sovereignty and separates the hydrocarbon 'haves' from the 'have-nots'. It has led to the major part of proved global oil reserves being booked by National or State Oil Companies (NOCs). To illustrate the change of ownership, in 1971 NOCs held 30% of total reserves while International Oil Companies (IOCs) held 70%. Today, NOCs have increased their share to 93% while IOCs hold 7%[1]. What could have caused such a dramatic reversal in fortune?

Since the early 1900s, the importance of oil in financial, political and strategic matters has been bubbling up to the surface. Eventually, this led to a pressing need for producing states to control oil. Mexico was first to 'shut' the Curtain wih President Cardenas nationalising its oil assets and forming the wholly state-owned Pemex (Petróleos Mexicanos) in 1938[2]. By 1960, resource sovereignty had fully matured into a global force and the Central Bank of Oil[3] – OPEC (Organisation of Petroleum Exporting Countries) – was created.

The effects of the Oil Curtain have been a blunting of IOC access to oil and a partial blurring of the distinction between NOCs and IOCs. As the spheres of action of both types of companies increasingly overlap, the industry has become more geographically dispersed and institutionally fragmented. Not least, the Oil Curtain has driven certain IOCs to metamorphose into energy companies.

The Oil Is Ours

'The oil is ours' reads a sign as you leave Rio de Janeiro on the road to the oilfield city of Macaé. That sign is not a historic throwback or juvenile street graffiti, but a modern official billboard paid for by the Brazilian government. Its nationalistic message is that oil, and oil wealth, are too important to be left to foreigners and external market forces. This message is a recurrent one found worldwide. It is just the language and symbolism that changes; Russia's Shtokman field, jobs for the boys; Niger Delta, moralists decrying the excesses of ex-pats; PdVSA and Bolivia; gringo go home.

Consider Shtokman and the decision of the Russian government to develop it alone – this is a clear message that the gas reserves could and would be developed without outside help which could otherwise be perceived as 'dependence' on foreign oil companies. Continuing unrest in the Niger Delta points to a different dynamic between regional and federal revenue sharing but nonetheless still nationalism. Bolivia's nationalisation of its Gas industry sends the same clear message. What is interesting is that both fully privatised and part-privatised companies were affected. StatoilHydro bid for Shtokman and was seen as the front runner and Petrobras invested heavily in Bolivia from Exploration and Production (E & P) to pipelines to marketing. In Venezuela and the Niger delta, the effects were felt by IOCs Exxon Mobil and Shell[4].

Figure 1 - President Lula Commemorates Brazil's Self-Sufficiency

Humble Oil

Oil has come a long way from its humble roots. Until the early 1900s, it was just a cheap fuel for lamps and heaters. How then could it be transformed into a strategic resource and military necessity within a decade? This rapid change was due to the convenience with which oil could be stored and transported, coupled with its high energy density. It was the most efficient fuel that mankind had discovered—the perfect fuel for the internal combustion engine and mechanised transportation. By 1911, it had replaced coal as the preferred fuel for the British Royal Navy. By 1918, other navies had quickly followed suit, creating a speed and logistics advantage that ultimately led to victory to those that used it. Accompanying the new-found status of diesel oil and gasoline as the fuels-of-choice for the war machine was the struggle to secure supply amidst the geopolitical upheaval of the times. In fact, it has been postulated that fuel shortages, not the Allies' military prowess, led to the ultimate demise of the Axis powers in World War II. The race had begun[5].

Makeover

Principally driven by the British, French and American governments, numerous oil companies were set the task of securing oil supply for their countries' needs. It was through ownership of concessions in developing countries, and predominantly in the Middle East and Far East, that the IOCs grew.

Known as the 'Seven-Sisters*,' – a term coined by the Italian oil tycoon Enrico Mattei referring to Exxon (Esso), Shell, British Petroleum (BP), Gulf, Texaco, Mobil and Socal (Chevron – plus an eighth, the Compagnie Francaise Des Pétroles (CFP-Total)[6]– these companies raced to find 'the prize'[7].

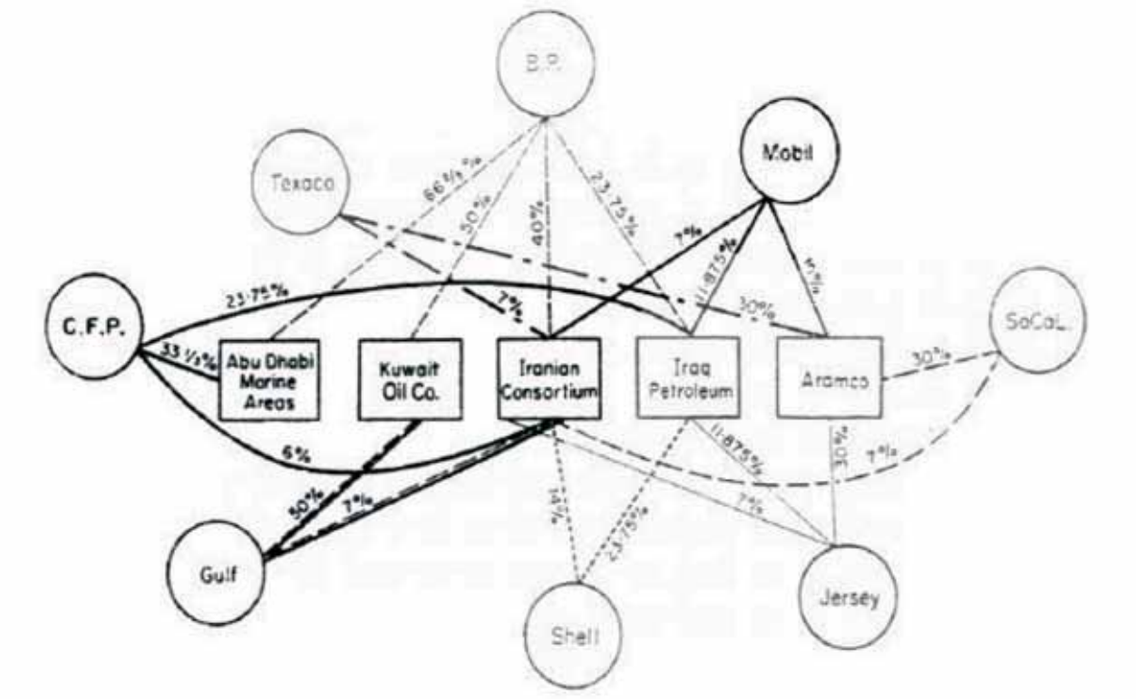


Figure 2 - Ownership Links Between Major IOCs (including Compagnie Française des Pétroles) and the Major Producing Companies in the Middle East after Edith Penrose, 1966

During this growth period, the IOCs made huge strikes in oil and rapidly drilled the wells and built the pipelines and refineries that were needed to turn the flow of oil into revenue. This was undoubtedly the golden period of the IOCs but, despite expert negotiations and justifications, the geopolitical manoeuvering was being noticed by the producing countries.

Seeds of Discontent

In the period between the two world wars, more and more countries began realising their futures were contingent on controlling their own resources, oil especially. At the vanguard of this realization was President Cardenas of Mexico[8,9].

The seeds of nationalisation had been sown by Mexico in 1934 when it forcibly took over the shareholdings of foreign oil companies operating in Mexico resulting in the creation of Pemex which became the first 'nationalised oil company'. Venezuela and Iran soon joined Mexico by re-nationalising their hydrocarbons.

Winds of Change

By the end of the Second World War in 1945, the knowledge that oil was of great commercial and strategic importance was commonplace. Oil was associated with vast revenue flows as well as having kept the 'war-machine' running. Consequently, colonial powers sought to control oil supplies.

In the post-war period, however, the winds of political change had swept aside the old colonial order whose political leaders acquiesced to foreign clients and replaced them with vocal nationalists who advocated sovereignty and independence. Exemplifying this were the strong voices of Gandhi in the Indian subcontinent, as well as Nasser and the Ba'ath party in the Arab states.

Viewed through the lens of political independence, control over natural resources had become an urgent necessity and, despite geographic and ethnic separations, a unified and growing chorus emerged with Mossadegh in Iran, Qasim in Iraq, Perez Alfonso in Venezuela and Tariki in Saudi Arabia all seeking to review oil contracts[10,11,12].

Initially, these individuals and countries acted alone, but as events unfolded affecting them all, they became increasingly united. The nationalist's central message was clear; oil was too important to leave in the hands of foreigners[13]. There was a need to regulate 'oil-rents' and end arbitrary payments from foreign oil companies.

Nationalist thinking was shaped threefold. Firstly, deals favoured foreign oil companies and foreign governments, not producing states. Foreign oil companies also controlled an outward flow of profits which were often the greater part of the producing countries' Gross Domestic Product (GDP). Generally, beneficiaries were foreign governments either directly through shareholder dividends or indirectly through taxes. Secondly, foreigners took vital political decisions affecting the sovereignty of producing countries. Oil production, foreign exchange earnings through oil sales, and ultimately, national debt were unilaterally dictated by foreign oil companies. Lastly, the military and naval campaigns of the Second World War, combined with the utility of oil in general transportation, left no doubt that oil was a primary strategic asset.

These factors created resentment among the political elites and the disenfranchised in producing countries leading to the conviction among producing states that oil profits should be shared equally between producing states that had territorial ownership of resources and IOCs who conducted E & P activities for oil[14]. Producing countries became united; the old deals had to be undone. New deals would treat territorial owners of resources and the IOCs as equals.

Sovereignty Over Resources

Financial, political and strategic factors acted as a catalyst for resource nationalisation, most notably with Iran and Venezuela taking their first steps toward sovereignty during the fifties. In Iran, the government nationalised the oil assets of Anglo-Persian (the precursor to British Petroleum). In Venezuela, the government established the famous '50/50' petroleum legislation that split oil revenues affecting US oil companies. Shortly after, Saudi Arabia, Algeria, Iraq and Libya followed suit[15].

Nationalisation in Teheran and the reformulation of oil revenues in Caracas were pivotal events that directed the founders-to-be of OPEC – Juan Perez-Alfonzo, the Venezuelan Oil Minister, and Abdullah Tariki, the Saudi Arabian Oil Minister – to seek a mechanism that would stabilise prices. They found the solution in a global equivalent of the Texas Railroad Commission, which had successfully controlled US over-supply of oil to stabilise prices[16].

The Compacto

During the Arab Oil Congress meeting in Cairo, Egypt in April 1959, Tariki and Perez-Alfonzo met to discuss what had been pressing so heavily on their minds. The two gentlemen had both reached the conclusion that the 50/50 principle should be replaced by a 60/40 split in favour of the producers. Within a year, the two men created the 'Compacto Petrolero' – an 'Oil Commission' that would permanently tip the balance of power in favour of producers. In some ways, this was the precursor to the Oil Curtain – the Compacto reshaped NOCs by aiming for a 60% share of profits. In due course by integrating their E & P, distribution, refining, transportation and retail operations, the NOCs would learn to compete with the IOCs[17].

Birth of OPEC

Of course, the IOCs were avidly paying attention to the 'Compacto'. Despite feigning disinterest in events, they turned to the spot markets and cut oil prices. Anglo-Persian (BP) had cut prices on the eve of the Arab congress meeting. Then, Standard Oil of NJ (Exxon) unilaterally cut the posted price of oil. Such a Machiavellian move would immediately affect the pockets and pride of producers, facts that were not lost on the decision makers who elected to keep the producers in the dark.

Rude words could have been a fitting response and perhaps, moves such as those that the oil companies had taken would have caused Alfonzo to use such words to describe oil politic[18].

In any event, the cuts prompted a united response and a different kind of swearing. Iraq invited several major petroleum exporting countries namely Iran, Venezuela, Saudi Arabia and Kuwait to Baghdad for a historic meeting which led to the birth of OPEC on September 14, 1960.

OPEC's first resolution pointed to the oil companies as the culprits: 'That members can no longer remain indifferent to the attitude heretofore adopted by the oil companies in affecting price modifications; that members shall demand that oil companies maintain their prices steady and free from all unnecessary fluctuation; that members shall endeavour, by all means available to them, to restore present prices to the levels prevailing before the reductions'[19].

The Princes Taught a Lesson

After the Second World War, the independence of former colonies sent out a shockwave —resource nationalisation. This in turn, created OPEC which signaled a decline in the hegemony of IOCs globally.

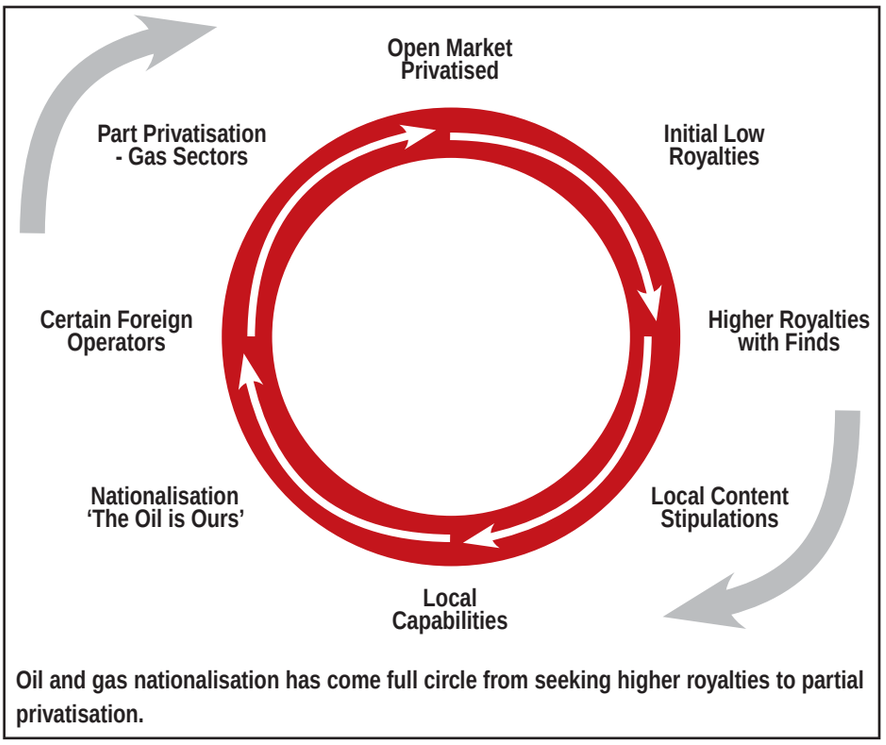


Figure 3 - Modern National Oil and Gas Policy

By 1970, the oil companies were still enjoying a princely existence but only just. Between 1960 and 1966, their share of oil production outside North America and the Former Soviet Union (FSU) countries, had increased from 72% to 76%, leaving 24% for the NOCs[20].

Oil company profits, despite complex justifications to OPEC and despite falling prices, were still high compared to most other industries. Rates of return for most IOCs were higher in 1966 than in 1960[21], and IOCs were able to finance most E & P as well as refining, retail and petrochemicals out of crude oil profits made abroad. The IOCs argued with OPEC that the retailing network was needed to create markets for OPEC oil, which would otherwise go unsold; however, it was the scale of repatriated profits that were ultimately responsible for unraveling the IOCs' concessions[22].

Sleeping Giant

The potency of OPEC remained dormant for a decade. In November 1962, OPEC was registered with the United Nations Secretariat[23]. Yet, it was not until the mid-1970s that a growing group of countries nationalised (or in some cases re-nationalised) their hydrocarbon industries. In 1973, it was the combination of Libyan radicalism and an Arab oil embargo precipitated by US support for Israel in the Arab-Israeli war, that within a ten-month period in 1974, culminated in the price of a barrel of oil rising by 228 per cent[24].

The old order had given way to the new.

Between 1970 and 1976, nearly 20 countries asserted national sovereignty over their operations[25]. In February 1971 after acrimonious disputes about prices, Algeria nationalised all French interests within its territory[26]. Shortly after, Libya announced the nationalisation of all BP's assets. This has continued to the present period where, most recently, Venezuela and Bolivia have nationalised IOC oil assets[27].

Driven by the need to develop gas reserves (to meet growing national and international demand for gas and to keep oil for exports), many countries had slowly relaxed national controls and through joint ventures, contracts with service companies and, exceptionally, ownership licences, larger oil companies were allowed to return to previously nationalised oil markets[28].

Modern national oil policy has come full circle (see Figure 3). It has evolved from seeking equal treatment to maximising royalties to stipulating local content to full re-nationalisation and now to partial privatisation for gas developments.

Yet in the latest period, nationalisation has resurged and

this can be seen clearly in Russia's decision to develop the Shtokman field alone and remove certain IOCs from the Sakhalin development, while in Bolivia and Venezuela oil companies have had their licences revoked and lost production. Nationalisation has even surfaced in the North Sea with Norway's government-controlled Statoil conducting a reverse takeover of NorskHydro. The Oil Curtain has spread.

As modernity spreads, lifestyles that were once confined to wealthy classes in wealthy countries are now found up and down social classes and across the globe. Think China and India. Together this relentless demand for oil and gas, which was already a strategic resource, has meant that oil and gas have become the world's most desired commodities.

In 2008, oil prices broke through the US $125 per barrel level peaking at a ceiling of US $147 before tumbling back to US $35 all within a six month period. Nevertheless, it is easy to forget that oil is cyclical and therefore it is only a question of time before it goes up. The only question is whether the present down cycle has a prolonged hard landing from the peak[29].

New Seven Sisters

Nowadays, OPEC decisions get as much ink as those of major central banks[30]. Yet beyond the paparazzi flashes and news-wire headlines, how important will OPEC and NOCs be for future oil supply? Realistically, the production of OPEC and certain NOCs will be vital for several generations to come. To understand that reality, simply look at (see Figure 4) the top ten reserve holders worldwide: Saudi Arabia, Iran, Iraq, Kuwait, UAE, Venezuela, Russia, Libya, Kazhkstan and Nigeria. Seven of these countries—the first six and Libya—are all

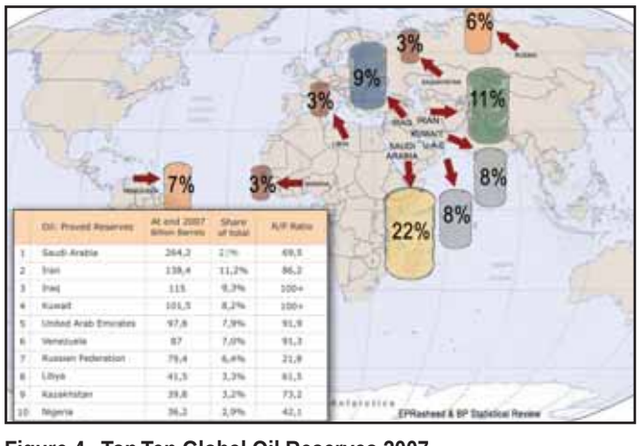


Figure 4 - Top Ten Global Oil Reserves 2007

OPEC members. To see how important these new Seven Sisters are to future oil supplies, consider the reserves to production column (Figure 4) to see how many of today's top ten global reserve holders are likely to be producers in the US Energy Information Administration (EIA) Energy Reference Case year of 2030[31].

At that time, I will be 60 years old and probably writing about the world's next 25 years of oil production. More to the point of todays' top ten oil reserve holders, Russia will have dropped off the list while the new seven sisters and OPEC will still be producing away. What about the other current major producers? Canada has 22.9 years, the US has 11.7 years and Mexico has 9.6 years of oil reserves left at current production rates. Upshot: OPEC and the new Seven Sisters will grow both home and abroad. NOCs may not become global household brands, but they have set the trend that restricts IOC access to oil, and lately, the dividing line between the two is not so clear.

Fuzzy Logic

The fuzziness between private and state oil companies stems from the NOCs that have 'gone global'. On the one hand, for certain companies the logic and returns of going global are compelling; add new production and export 'home-grown' technology. Yet, on the other hand, there is the risk of sudden nationalisation. Once wellheads, fields, pipelines and refineries are built, they cannot be dismantled and sent back 'home'. In the event of political change or a major dispute, the oil company's bargaining power is effectively reduced. Any share or interest it may have in production can only be sold off to the state which then becomes a question of expedient valuations rather than ownership.

What actually constitutes a NOC? Is it 100% state ownership or just a state majority? What if the company floats on the world's stock markets and has private shareholders yet retains a state majority?

The distinction depends on whoever holds 51% or more of voting shares and controls overall decision making power. If the majority shareholder is a government or state, the company must answer to them; therefore, such a company is defined a NOC. The opposite also applies. If the company's 51% voting majority is privately held or listed, it would be defined an IOC.

Shareholder distinctions shed light on the responsibilities of each company too. NOCs have a strong responsibility to steward oil wealth to meet the needs of

a given nation and its population in a sustainable way. IOCs focus primarily on maximising returns; social responsibility is important, but not to the same degree as NOCs. Most people in the industry accept that profits must be balanced with social responsibility. Private shareholders generally accept this too. Corporate Social Responsibility (CSR) programmes within IOCs are abundant and this type of social spending does not raise investors' eyebrows as long as returns are healthy. Part-privatised NOCs fall into this category also. Just how much social responsibility is deemed healthy depends on the shareholders.

We Speak Your Language

Notable NOCs such as Petrobras and CNPC operate well beyond their home territories. Both companies not only retain majority government stakes, but also raise capital using a canny combination of state finance and international financial markets to develop domestic and foreign reserves. Where they really excel is by competing internationally for capital and upstream acreage and applying their unique technologies and know-how.

Accessing reserves or holding on to them is the producer's top challenge. Consumption is a given. Subsequently, finance, Human Resources (HR), technology and processes can be acquired.

Undoubtedly, production is one end of a transaction; consumers are needed too. Both depend on each other for the respective stability of demand and supply. Whatever affects the economies of oil consumers ripples through to producers and vice versa. The ultimate interests of oil producers and consumers, therefore, always converges in promoting stability of the worldwide economic framework and minimising economic shocks.

The upshot is that reserve holders or producers, rather than retailers, determine rules. In this way, accessing reserves or holding on to them has become the pro-ducer's number one challenge—HR, technology, vertical integration and process efficiencies can all be subsequently acquired.

NOCs Go Global

Naturally then it is a 'no-brainer' for NOCs with global ambitions to compete for foreign reserves and production. Entering this competition makes sense for those NOCs such as Petrobras or the China National Petroleum Corporation (CNPC) that have limited reserves or high production costs at 'home' or where they can export 'home-grown' technologies abroad. It does not make sense for the new Seven Sisters who have abundant domestic reserves at relatively low production costs. In the latter, it makes more sense to stay 'home' and develop national reserves.

In the old days, it was fair to say that the IOCs conferred access to reserves. They had the technology, know-how and capital to create wealth from a natural resource. Naturally, they bargained hard and got the lion's share. Those 'old ways' show that oil reserve holders used to recognise IOCs as equals, perhaps even as holding the upper hand as IOC participation was required for revenues to be realised[32].

But Where Do the IOCs Fit Into All of This Today?

Much has been written on IOCs and our focus is on the growth of the NOCs which is far less documented; however, as the two are inextricably linked, it is worth briefly extracting pivotal events that are common denominators. It is widely accepted that the oil industry's fate was sealed by growing demand for transportation (military and consumer) and the steady supply of oil from refineries, pipelines and fields worldwide.

Numerous discoveries were made by geologists and drillers made production possible by always finding a way. In fact, the vertical integration and camaraderie of an inter-disciplinary approach positioned IOCs so well that it was almost as if each had its own principality of petroleum production[33].

Original Seven Sisters

A decade ago the price of a barrel of oil languished at US $10. This triggered 'mergeritis' and reformed the original Seven Sisters. During the 1990s, the new 'prize' for these companies was finding synergies and economies of scale. Management consultants were set the task of merging these great disparate entities and analysts evaluated the mergers in terms of restructuring and costs.

In the corporate cost-cutting that ensued, locations and operations were rationalised. Many IOCs consolidated their international operations in Houston. Research and Development (R & D), technology activities and technical disciplines were seen as unnecessary fixed costs that could be more profitably outsourced. At that time, only a handful of voices questioned rationalisation especially that related to technology R & D; it made sense

financially and operationally. Ironically, technical outsourcing would strengthen the Oil Curtain and return to haunt IOCs.

Metamorphosis Begins

As the Oil Curtain fell, the IOCs became accustomed to a gradually shrinking pool of accessible oil reserves that were ever more difficult and costly to produce. This initiated the metamorphosis of the IOC with progressive companies such as BP and Shell repositioning themselves for the future, not just because they had seen 'beyond petroleum' but because they had felt 'the Oil Curtain' fall. This, however, does not imply the fall of the IOCs; there are still plenty of global E & P opportunities around, albeit tempered by lower margins due to higher cost and technical challenges.

Oil companies' future profits (and share prices) depend on production and reserves. As older fields decline, companies must find new production and decommission older structures. Our earlier look at the global reserves base shows the true significance of NOCs. Where reserves are institutionally accessible by IOCs, they are accessible only at considerably higher costs typified by technically challenging projects in ultra-deepwaters or the Arctic. In this way IOC 'replacement' costs tend to rise faster than NOC replacement costs. However, this is not always true as certain NOCs that have deepwater or heavy oil reserves may have comparable costs to those of IOCs.

The metamorphosis of more progressive IOCs into energy companies are clear trends for the future of the industry. Natural gas emerges as a bridge to alternates with certain IOCs quietly stacking up an impressive array of gas technologies and know-how. Here, BP has distinguished itself in LNG and solar know-how, while Shell has done the same in Gas-to-Liquids (GTL) and hydrogen (see *Chapter 13: Renewable Energy*).

Houston, We Have a Capital

As the industry consolidated, Houston emerged as its capital city and its downtown skyline became synonymous with the global oil business. Today, Houston represents the oil consumption capital of the world. The oil production capital lies elsewhere. Characterised by a modest skyline and towering reserves, Dhahran takes that title. Moscow becomes the natural gas production capital and Doha that of Liquefied Natural Gas (LNG). Almaty, Baku, Bushehr, Lagos, Macae, Maracaibo are other emerging oil cities as the industry realigns. The combination of oil technology as a commodity, ascendant oil prices and the realignment of cities has strengthened the Oil Curtain. Ironically, as oil production technology becomes freely available on the market, access to oil reserves becomes more restricted.

Consolidation

Whenever the price of crude oil falls below a certain cut-off point, operators cut budgets and work orders, and oil service and supply companies enter into a period where revenues drop sharply. For many oil-related companies, this means a fall in their share yields and ultimately a drop in stock prices. This increases the likelihood of takeover in two ways. First, asset rich companies with poor liquidity or cash flow difficulties find themselves financially exposed and become prime targets for takeovers and asset stripping. Second, product or concept rich companies who have often borne high R & D costs are swallowed up by larger organisations seeking to add value to their operations and increase market shares[35].

In this way, during the 1990s low oil price environment (US $10/bbl)[36], many upstream companies looked to the stock markets to increase oil and gas revenues effectively, by acquiring listed companies whose share price belied their reserve values. For this reason, cost reduction was an imperative[37] and 'performance optimisation' and 'well-cost reduction' became strategic. Nowhere was this strategy more relevant than in high-cost environments such as the North Western European Continental Shelf. Ever since the late 1980s, this area has been characterised by the need to cut costs and to advance technology. In the 1990s, the scale of cost-cutting was widespread and was exemplified by the shedding of labour, outsourcing, contractual terminations and 'mergeritis'. The industry even institutionalised cost reduction through the creation of initiatives such as Cost Reduction in the New Era (CRINE) in the UK sector and NORSOK in the Norwegian sector[38].

Mergeritis

This gave rise to 'mergeritis' which re-formed the world's largest oil companies—Exxon and Mobil, Chevron and Texaco, BP, Amoco and Arco. Management consultants were set the task of merging these great entities by generating synergies and economies of scale. Analysts evaluated the mergers in terms of restructuring and cost-cutting to justify the acquisition costs and remain competitive against the low oil price[39].

Figure 5 - Downtown View of Houston (EPRasheed)

In the corporate cost-cutting that ensued, locations and operations were rationalised. This led to Houston's growth and importance within the oilfield. Many IOCs consolidated their international operations in Houston and it was the prevalent wisdom that R & D technology activities could be cast-off as unnecessary fixed costs that could be more profitably outsourced. At that time, the oil company rationalisation made sense financially and operationally.

Outsourcing Technology

Technological advancement and innovation is typical of high-cost industries where saving time and money is vital to the commercial success of companies and the industry itself. These factors have played a crucial part in the advancements made in well trajectories—such as seismic, multilateral, Extended Reach Drilling (ERD), horizontal and designer wells—and the enabling technologies to optimise production, and in so doing, increase profitability.

As operators became leaner, well profiles followed suit and the requirements for competitive tenders, data simulation and risk analysis increased. The bottom line was that service companies were being asked to contribute more value than ever before, in order to reduce well cost and optimise performance. In this way, the IOCs outsourced more and more, not just technology niches, but certain technical disciplines such as drilling or production engineering as well[40].

Service Sector Grows

Service companies grew in the interim. Simultaneously, they kept a watchful eye on US and international projects being planned out of Houston and carefully noted cast-off R & D projects with a view to commercialisation. In this way, Houston evolved as the E & P capital of the oil industry and its downtown skyline characterised worldwide operations.

Ironically, it has been the convergence of technology outsourcing and ascendant oil prices that have strengthened the Oil Curtain. This is the self-fulfilling prophecy; as production technology becomes easier to get on the open market, oil access becomes more restricted.

Corporate Social Responsibility (CSR)

There was always a constant suspicion amongst producing countries that the IOCs were extensions of foreign governments, acting out colonial policy as required. This suspicion may have contributed to oil companies engaging in social programmes. It is unclear which IOC started wider social engagement such as education, hospitals and the development of local skills. What is quite clear is that such engagement gave rise to a wide ranging set of IOC initiatives such as sustainable development or CSR which were designed to ameliorate a series of sore issues that were rooted in inequalities between the producers and the IOCs. These ranged from the setting of volumes of oil exports, the repatriation of profits, the heavy dependence on imported goods and services to the princely lifestyle of foreigners posted to poor countries.

Sustainable development has grown to encompass the building of local capacity that may export technology and know-how, and the savings and investments of oil profits into non-oil related industries. Essentially, it means enfranchising locals in most aspects of the oil company's business either locally owned or managed[41].

It can be argued that the geopolitical tension that lies at the heart of certain disputes results from the uneven

distribution of oil-wealth. If that were not enough, the fact that oil is a finite wealth generator makes things worse. This ultimately highlights the undoing of any CSR initiative or investment. As long as disparities in the distribution of oil-wealth exist, CSR programmes are constantly in peril of being perceived at best as arbitrary acts of philanthropy or at worst empty exercises in public relations[42].

The politics of revenue distribution can be a potential minefield for oil companies. They must satisfy the powers that be – state governments – and reconcile the valid needs of local groups, whether these are communities that have right-of-way over pipelines or those that live in the state that produces oil or gas. If there are competing ethnic groups or self-perpetuating elites coexisting with poverty stricken masses, the oil company is sitting on a time-bomb. Paradoxically, sometimes it is the case that even if oil companies keep locals happy and build local industries, the government may still nationalise.

NOC/IOC—Corporate Transparency

Transparency or the lack of it was also a major influencer in the changing behaviour of IOCs. The IOCs saw that they were being targeted by savvy lobbyists and environmental activists that could impact their image (and share price) in their home countries. This coupled with anti-corporate demonstrations even led some IOCs (BP) to publish sensitive figures regarding tax payments abroad made to foreign governments in regard of operating agreements. Further, some oil companies aligned themselves to protecting human rights by joining the UN World Compact (Petrobras). Legislation that prevents corruption and emphasises due diligence has tightened up and defined the limits of ethical behaviour for companies acting abroad, and this influence has permeated the industry as a whole which has high levels of corporate governance[43].

We have seen that the real challenge facing the IOCs is that they face increasingly difficult operating conditions in E & P activities, not just regarding the physical landscape but rather a much more wide-ranging panorama of challenges. These include decommissioning, booking new reserves in a narrowing opportunity base, a socio economic and occasionally politically hostile landscape, a lack of E & P technology as a differentiator and environmental lobbyists. Perhaps, most of all, nationalisation has made operations more difficult. Here we trace the transformation of the NOC from quiet man to international giant[44].

NOC/IOC Distinctions

The distinction between NOCs and IOCs hinges on whether the NOC majority shareholder is the state, and therefore must ultimately answer to the state as opposed to a privately held IOC which answers to majority private shareholders only. This distinction explains why NOCs have a responsibility to meet the needs of the nation and the population that owns them, while maximising profit.

Nowadays, the industry recognises that profits must be balanced with social responsibility and private shareholders generally accept this. Most major IOCs have CSR programmes and this type of spending is not generally questioned by investors, as long as returns are healthy. Part-privatised NOCs fall into this category also. In the case studies below, we look at NOC concepts of sustainability and social responsibility from two major oil exporters—Saudi Aramco and PdVSA. Two further case studies look at the part-privatised StatoilHydro and Petrobras as they compete internationally in the US Gulf of Mexico (GOM) and apply the technical respective differentiators of deepwater E & P technology[45].

Saudi Aramco

Considered by many to be the world's largest oil company and the world's largest NOC, Saudi Aramco controls one-quarter of all world hydrocarbon reserves and plays a vital role in fuelling Saudi Arabia's socio economic growth. In this context, Saudi Aramco routinely evaluates its development decisions on a combination of corporate and national contributions; for example, a petrochemical project with a Japanese chemical company contributes at both these levels by seeking to transform the Rabigh Refinery in Saudi Arabia into an integrated refining and petrochemical complex.

The evaluation showed that although Rabigh would be profitable, it was not the most profitable investment opportunity that Saudi Aramco was considering. What Rabigh provided, however, was 'the most combined value to the company and the nation'. The national component means that Saudi Arabian society will benefit from the foreign investment, the new jobs created and additional revenues[46]. The corporate component means that Saudi Aramco will extend its petroleum value chain, upgrade oil processing and make its portfolio more profitable[47].

In the area of Key Performance Indicators (KPIs), Saudi

Aramco's approach is to use IOC yardsticks in order to be best-in-class in areas such as finding and lifting costs, corporate governance and financial discipline[48].

Venezuela

For Venezuela's PdVSA, sustainability is stated as being central to its existence[49]. Its definition of sustainability considers oil and gas resources from both a production and consumption perspective. PdVSA's stated policy is to regulate production of oil and gas so that E & P processes are optimised, while certain blocks are conserved for the benefit of future generations of both consumers and producers. Its central belief is that because oil is a finite natural resource, producing countries must exercise the sovereign right to regulate production levels so that benefits accrue to current and future generations of indigenous people.

PdVSA also sees its role as educational and to show consumers that oil is not a commodity that operates according to free market rules. It contends that energy markets do not operate in a free market fashion.

PdVSA recognizes that stability should exist in the market, but this can only occur if there is political, economic and particularly social stability. It also asks consumers to consider whether they are consuming energy in an efficient way.

For PdVSA, sustainability must include policies of integration that allow poorer countries to have access to oil and gas. This has been the reasoning behind the Petrocaribe initiative by which Venezuela supplies 200,000 barrels of oil per day (bbl/d) to more than 20 of the smallest countries of Latin America and the Caribbean under special financing[50].

For PdVSA, 'unrestricted access to (the) energy is not the same thing as sustainable access'. The company views the current model as consumers demanding unrestricted access to natural resources, but not allowing resource holders to improve the socio-economic standing of their people. According to the company, this model is characterised by infrastructure bottlenecks resulting from decades of under-investment caused mainly when IOCs held unrestricted access to reserves. PdVSA's view is that sustainability of access must mean that poor countries should be able to access sustainable energy sources[51].

Petrobras

During 2006 and Lula de Silva's successful re-election campaign, Petrobras and self-sufficiency featured prominently. Even before the election, Petrobras was participating in the Brazilian governments 'No Hunger' program. The part-privatised NOC has been playing a greater role in curing Brazil's social ills. As Brazil's largest company, the logic is understandable. Over the years, Petrobras has added tens of billions of US dollars to government coffers in the form of taxes, fees and social contributions. It is also helping by generating thousands of jobs and boosting the local economy by giving Brazilian companies preference for offshore projects[52].

This swing towards nationalism is also accompanied

Figure 6 - Rabigh Refinery (Courtesy of Saudi Aramco)

by a skepticism that the opening of the Brazilian E & P sector resulted in little or no gain for Brazil as production or employment increases have been minimal. Brazil, however, has certainly benefitted from technology transferred by IOCs from other areas and this would not have occurred had Petrobras' monopoly not been broken.

The arrival of the IOCs brought knowledge gained from international offshore operations and diverse basins, knowledge that was limited in Brazil. Many techniques that have been proven elsewhere—for example, ERD—are only just emerging on the Brazilian oilfield. IOCs were also accompanied by a raft of suppliers and service companies keen to offer specialised technology. Without an initial hand from IOCs to enter Brazil, many service companies would be put off by the monolithic appearance of Petrobras[53].

Appealing on the one hand, and dangerous on the other, the logic of nationalism can be difficult to counter. Part of the explanation why offshore vessels on the international market are competitively priced is because foreign governments grant favorable loans to their shipyards. Given similar credit terms, Brazilian companies can compete too. That's clear enough but the danger is that, although nationalism can boost the economy, it can also stifle new ideas.

With a 'people before profit' attitude, Guilherme Estrella (Petrobras E & P Director) has made no secret of being more concerned with generating stable and long-term oilfield employment than opening up the Brazilian E & P market further. This is good news for the offshore industry as a whole because Petrobras is the major employer and trainer of petroleum engineers in Brazil.

The tightrope that Petrobras must walk is balancing the interests of two very different kinds of shareholders. The Brazilian government still owns a majority 51% of ordinary shares while the remainder is held privately. This kind of balancing is ultimately made easier because from both a medium and long term perspective, Petrobras is in an enviable position. It has helped the country reach self-sufficiency and added reserves, while growing its operations in the international arena, especially the US.

Petrobras in the GOM

Petrobras America is currently involved in four business areas which are upstream, trading, procurement and refining. Over the last four to five years, Petrobras has implemented a strategy which looked for specific core areas where it could apply its technology and expertise. These elements have proven critical to success; in frontier opportunities and also 'hard to access areas', as well as four core areas in the GOM (US Waters). One of the options for developments is a phased Floating Production Storage Offloading vessel (FPSO) programme similar to Brazil where a FPSO could sail away in case of a hurricane and reconnect after storms.

According to Petrobras its goal is 'to concentrate in key areas, certain trends and certain plays where Petrobras is bound to be a significant player'[54].

By spreading risk, Petrobras plans to build a portfolio through exploration and not acquisitions. This means testing concepts such as Early Production Facilities (EPF) to get a better idea of the reservoir/production profile before going into full production. The innovative approach of Petrobras has been applied to the western part of the US GOM. This area had not seen a single well drilled for at least a decade as the industry's general understanding was that there was no merit in drilling. During the past decade, however, major technology improvements and better geological data have changed this. These areas are gas prone with most production coming from the very shallow formations and the Great White Shell development in deepwaters, but with nothing in between.

Seismic has highlighted interesting features, although these prospects have not been properly tested. For Petrobras, two key characteristics are repeatability and having options. Prospects which have similar characteristics, are important because they allow geologists to make inferences from one area to the other. This helps Petrobras to decide whether to drill more wells or not. Options are important too, i.e. where the oil company has eight or ten prospects, there is an option to drill and that limits risk[55].

Petrobras is using technologies and new ideas to build a successful portfolio by using deepwater knowledge, but also geologic modelling from other international areas, i.e. Colombia and the deepwater US GOM.

Petrobras Trading can be seen as a set of services for the group rather than a trading floor presence. It involves finding and developing markets for surplus production. Price oscillations allow Petrobras to access production and optimise its production profile. Increasing production of Marlim crude, which has an API of 19° to 22°,

means that the demand for Marlim to be processed in Brazilian refineries is set to go up as is Brazilian refining production; however, there is still a sufficient surplus of Marlim beyond that which can be handled by Brazilian refineries. This allows Petrobras America to sell and capture the best margins in the market.

Market surveys, intelligence and transactions are done by Petrobras Brazil but Petrobras America is the broker. Petrobras America gains title for certain products, i.e. gasoline and fuel oil, and sells these on. Petrobras America started a new refining business through the purchase of 50% of a refinery in Pasadena, Texas. The current capacity of 100,000 bbl/d is being increased through substantial investments that will allow for a further 70,000 bbl/d. Petrobras continues looking to both upstream and downstream opportunities within the US, which is the world's largest consumer and a strategic market[56].

StatoilHydro

StatoilHydro is the Norwegian oil company and views its introduction to the stock exchange in Norway and in the US as a favourable move. According to StatoilHydro, it has the same requirements and terms for operation as any IOC while having the Norwegian government as its main owner gives it unique advantages, as it is not up for sale[57].

When many IOCs were cutting their R & D functions to reduce costs, StatoilHydro invested more in its R & D facilities and pioneered aspects of subsea and deepwater production. This has helped the company develop certain technology inventions. Part of this is due to the close relations all operators on the Norwegian Continental Shelf have with government authorities, who challenge operators to overcome new obstacles. The company's goals are for the US GOM to become a core area for StatoilHydro by 2012 with production of 100,000 bbl/d. It cites a favourable fiscal regime, stable government and yet—to find resources as key elements to meeting growth targets in the US GOM.

StatoilHydro's development strategy for the US involves a combination of farm-ins and acquisitions. This started three years ago with the Chevron farm-in within the Perdido Fold Belt, which resulted in the Tiger discovery. This was followed by the acquisition of Encana assets. At the same time, StatoilHydro farmed-in about 70 leases in the Walker Ridge area with ExxonMobil. This strategy continues with participation in the lease sales in the deepwater GOM area.

It also has a growing business feeding LNG from the Snøhvit field in Norway and from its Algerian assets to the Cove Point LNG terminal in Maryland.

The company has imported a lot of Norwegian offshore technologies that may be applicable for use in deepwater GOM; however, further tests are needed to prove that usage in Norwegian offshore water depths of 300-500 m are suitable for much deeper US GOM waters of 2000-2500 m. Increased recovery may be possible by using a subsea processing, subsea boosting and injection system and FPSOs with risers that have the ability to disconnect. This may be a good solution to secure equipment during extreme weather conditions like hurricanes. Ultimately, StatoilHydro has a wide variety of technologies at its disposal and those are likely to provide its international operations with a competitive edge.

China National Petroleum Corporation (CNPC)

CNPC, China's flagship oil company, plays an important role in China's oil and gas production and supply. Its oil and gas production accounts respectively for 57.7% and 78.3% of China's total output. CNPC is also a global player with E & P projects in Azerbaijan, Canada, Indonesia, Myanmar, Oman, Peru, Sudan, Thailand, Turkmenistan and Venezuela.

CNPC has bet heavily on R & D to increase E & P production and reduce risk in complex basins. It has developed solutions to improve recovery factors as well as reduce development costs. It has a strong sense of innovation and has technologies in reservoir characterisation, polymer and chemical-flooding. Other technologies include high-definition seismic, under-balanced drilling, ultra-deep well drilling rigs and high-tensile steel pipes. According to the company, by the end of 2007, CNPC had acquired 7,010 patents out of its 9,693 patent applications.

It holds proved reserves of 3.7 billion barrels of oil equivalent. Other relevant data include:

- Oil production: 2.75 million barrels of crude oil/day (MMbbl/d)
- Gas production: 5.6 billion cubic feet/day
- Oil reserves: 3.06 billion metric tonnes, and
- Gas reserves: 2,320.1 Bm^3.

Metamorphosis of IOCs

In the old days, IOCs conferred access and monetised oil reserves. IOCs alone had the technology, capital and know-how to tap the wealth of an unknown hidden natural resource. Naturally, they bargained hard and got the lion's share. Those 'old ways' show that oil reserve holders used to recognise IOC as equals, perhaps, even as holding the upper hand as the IOC was required for revenues to be realised[58].

Even before the Oil Curtain, some IOCs noted that the pool of accessible oil reserves would one day shrink. Progressive IOCs repositioned themselves for the future; some seeing 'beyond petroleum' and others shut out by the 'Oil Curtain'. This, however, does not imply the fall of IOCs. Some are perfectly adapted to evolve and there is still a healthy global E & P environment for them to adapt to.

The drawback is that this environment of extreme E & P has high replacement costs as margins are squeezed by technical challenges. Extreme E & P opportunities exist in ultra-deepwaters, Arctic, unconventionals and in a dazzling array of gas-related technologies. These include: LNG which mobilises and commercialises stranded reserves; biogas which is renewable through biologically produced methane; Compressed Natural Gas (CNG) and LPG, that provide fuel for the transport and power-generation sectors; and, GTL which offers high quality gasoline fuel.

Of the original seven sisters, most have already adapted to an extreme E & P environment. Going further, BP has distinguished itself in LNG and solar power, while Shell has distinguished itself in Gas to Liquids (GTLs) and hydrogen.

Undoubtedly, IOCs face increasingly challenging operations – extreme E & P. Additionally, there are a wide-ranging set of challenges such as decommissioning, booking new reserves in a narrowing opportunity base, a lack of E & P technology as a differentiator and environmental lobbyists. Perhaps, most of all, nationalisation and resource sovereignty, has made business more difficult.

Despite this, IOCs retain refineries, retailing networks, brands, and direct access to international consumers. Certain IOCs, for example BP and Shell, have continued to be early adopters of new technology. That is praiseworthy, because by supporting innovative new ideas and signposting applications[59], these IOCs have significantly contributed to many E & P innovations, i.e. rotary steerables and expandables across the industry. Those IOCs took risks to prove tools downhole and the benefits have been reaped by all types of oil companies.

Black Blessing

We have seen within a century how oil and gas have become the world's preferred energy source. Consequently, certain countries with the oil and gas wealth or the black blessing have benefitted. So which countries have made oil wealth a true blessing[60]?

Dubai and Stavanger are synonymous with oil wealth, but these cities also subtly show that the black blessing has been managed responsibly with a vision for the future. For these and other thriving cities, there are countless other stories of squandered oil-wealth and cities that have ended up as ghost towns. Yet, no single country's approach to the management of oil and gas has been perfect; it has been learned.

What works in one country is not necessarily the solution in another, but parallels and lessons exist. We shall see how the forces and needs acting on the North Sea were very different to those of the Arabian Peninsula. Each country's profile is unique but what emerges is a common lesson: oil revenues 'rollercoaster' and are subject to depletion.

Dutch Disease

Due to the highly specialised requirements of the petroleum industry, personnel and equipment are often imported. If you have a pressing deadline, it is easy to think 'don't reinvent the wheel, import'. This, however, is dangerous. Firstly, capital flows become wholly dependent on cyclical oil and gas revenues. Secondly, the creation of local jobs and local infrastructure is limited as workers and equipment are 'outsourced'. The few jobs that are created are fringe industries and are very much dependent on the migrant workers and can easily vanish. Thirdly, excessive imports and the petroleum industry itself can inflate costs so that locals are excluded from housing, social and other activities. This is a double-edged sword as the higher-paying-oil related activities push out other less lucrative activities. Without diversification, these negative factors expose a country's dependence on oil wealth. When oil prices fall, the consequences can be disastrous, i.e. Norway and UK in the 1986 crash.

Before Oil

When considering the North Sea – Stavanger, Norway,

Aberdeen, UK and the Arabian Peninsula – Dhahran, Saudi Arabia and Dubai or Abu Dhabi UAE it is revealing to see how these countries existed before oil.

All of these countries had very different socio-economic profiles; healthcare, disposable income, education levels, transport links and indeed internal infrastructures were severely limited.

Yet, in each the black blessing has improved lives within the space of a single generation and has led to the creation of new industries (see Figures 7, 8 and 9).

Pilgrims

In the Saudi Arabian peninsula, oil was discovered in the 1930s. At that time, exploration contracts for oil were scorned; in scorching desert temperatures, exploration was for a more valued resource, water.

Saudi Arabia had already been guaranteed an annual source of revenue due to the Hajj – the pilgrimage Muslims make to the city of Mecca; however, the country's infrastructure was underdeveloped which led to a weaker bargaining position. When the first contracts were signed, the Saudis received less than the equivalent of 5% royalties. With the discovery of oil and its growing geo-political importance, the Saudis' bargaining power increased.

Royalties grew to 50%. Other stipulations such as the improvement of transportation and telecommunication links followed. By the 1970s, the Saudis had started to buy-back the privatised oil company leading to the full ownership of Aramco and the country's reserves of 264 billion barrels of oil.

Figure 7 - Dubai's Palm Island

In reality, national oil policy has come full circle. It has evolved from seeking maximum royalties to stipulating local capacity to full re-nationalisation and now to partial privatisation for gas developments. To illustrate Saudi Aramco's local content, as of 2007 it had a total of 52,093 employees of which 45,464 were Saudis and 6,629 were expats. It has also signed gas exploration contracts with foreign oil companies such as Shell.

Gold and Pearls

In the UAE, a union of seven Emirates, the situation was different. Dubai had long been a regional trading hub and had far fewer reserves than Abu Dhabi which meant it quickly realised its economic future lay beyond its scarce oil reserves. Dubai's souks were known worldwide for all manner of commodities, especially gold and Arabian pearls. Dubai continued to profit from trading until the cultivation of artificial pearls and world recession caught up in the 1930s.

The quality, size and quantity of artificial pearls could be controlled in such a way that demand for them grew quickly. Commerce dropped in Dubai and it was no wonder that, when news reached the ruling family in the UAE and Dubai that oil exploration licences were being sold in Saudi, negotiations quickly followed.

With the fullness of time, this led to the discovery of reserves of approximately 98 billion barrels of oil in the UAE. Presently, Dubai has developed a policy of cluster economies which have resulted in flourishing financial services, tourism and IT sectors.

A Tale of Two Cities

Before oil, Aberdeen and Stavanger were economically stable albeit sleepy fishing and maritime towns. During the early 1960s when gas was first discovered (oil came afterwards) in the Grönigen field in the Dutch Sector of the North Sea, Norway had high employment, a current account surplus and low inflation. From a socio-economic perspective, there was no pressing need to explore for and develop oil and gas.

With the 1973 oil crisis and accompanying embargo, geologists started scrambling for North Sea seismic. This instability in global geopolitics set the scene for the upper hand in negotiations with the IOCs. When the Norwegians and Scots asked for rewards beyond taxes and royalties, the oilmen obliged.

Figure 8 - Abu Dhabi View from Emirates Palace

Figure 9 - Oil and Gas Wealth Is Not Necessarily A Trade-Off Against The Environment. There Are Wider Considerations (EPRasheed)

Differences Between the North Sea and Arabian Peninsula

The need to develop local knowledge was linked to the nightmarish operating conditions in Norway. In contrast, the Arabian Peninsula is an oilman's dream – punch a hole near a dome and chances are that oil will be struck. From the very start, these very different environments formed very different mindsets. This led to a historic laissez-faire approach to technology development in the Arabian Peninsula.

In contrast, Norwegian and British fields were located in the harsh North Sea, a dangerous environment where locating reservoirs was a costly, timely business. Here the application of technology made a vital difference. With good seismic, directional and real-time data, well construction costs could be halved. This was a compelling reason for the development of North Sea technology. In parallel, the gradual introduction of terms such as the famous '50% local content' stipulation in exploration contracts helped develop local content.

Game-Changing or Incremental Benefits?

Technology of every type was necessary in offshore Norway and UK. The need for reducing risks and cutting costs was acute and technology could change the nature of the game, magically making uneconomic reserves profitable. In the Arabian Peninsula, the benefits of offshore technology did not apply. While other onshore technologies could be applied their technical and financial gains were insufficient. An incremental gain in production or cost-reduction was not compelling enough for such technology to be used in the Arabian Peninsula.

North Sea offshore operations, for example, routinely cost in excess of US $200,000 per day including rig rental and crew costs. By contrast, onshore operations in the Arabian Peninsula do not often exceed US $100,000. Additionally, the profile of Arabian reservoirs, i.e. their production rates and overall production size, are order of magnitude greater than North Sea finds which leads to lower overall finding, development and lifting costs in the Arabian peninsula.

By the 1980s, greater emphasis was placed on local content and local capacity building within the Arabian peninsula. This trend had its roots in the North Sea.

Build Locally

It is worth highlighting that prior to the early 60s, there was no oil and gas industry whatsoever in the North Sea. Yet, today the industry is a prime mover in the Scottish and UK economy.

How did this transformation occur within a generation?

Figure 10 and 11 - Developments along Sheikh Zayed Rd Dubai (EPRasheed)

Figure 12 - Drilling Rig in the Middle East (EPRasheed)

Building local capabilities was always a 'must-have' for the North Sea. Eventually, this led to the creation of the service sector hub which exports oil and gas technology globally. At first, technologies were invented, tested and proven in the North Sea before being exported worldwide.

We have seen that until the mid 1960s, neither Norway nor the UK had an oil industry, but within years the chorus to create one was loud enough to be heard. In the early 70s, this led to the preferential use of local goods and services at times reaching 90% as required by law. In the early 70s, the Norwegians created Statoil, the operational oil company and as policy maker the Norwegian Petroleum Directorate (NPD). Accompanying this was a preferred policy for Norwegian goods and services coupled with a clause of transfer of know-how and research cooperation.

The UK and Norway's success in achieving high local content is largely due to these policies which have encouraged partnerships between foreign and domestic companies and made research programmes mandatory. Research has helped create smaller companies which have exported technology worldwide and grown. The University of Aberdeen Oil Centre lists 175 small companies working in the oil and gas sector. These range from small independents to technology companies.

In terms of production, Norway and the UK are very different. Norwegian oil and gas production has increased over the past decade to 3.1 MMbbl/d. The UK's oil production has fallen by 30% over the same period to current levels of 2 MMbbl/d. Yet, through demand for UK oilfield goods and services, the oil sector continues to generate substantial economic activity.

Smaller independents have entered the UK sector but the oil and gas industry has developed far more due to the formation of mechanical and petroleum engineering, academic and vocational training and associated consultancy services.

Seeds of Knowledge

Licensing terms for oil contracts stipulated the transfer of skills and competence to Norwegian companies. Personnel from Norsk Hydro, Saga and Statoil (these companies have merged into StatoilHydro) received training in the IOC training programmes and overseas postings.

The situation was slightly different for the UK as BP

already had international oil and gas exposure. In fact, this helped it discover and develop Forties (the largest North Sea UK field).

These seeds grew into the commercial success of numerous oil technology companies that export goods and services worldwide.

Technology Greenhouses

Today, there is a strong culture of oil and gas R & D; several well test sites and research companies exist. Illustrating this is the Bridge of Don Test site in Aberdeen, Rogaland Research and its test well in Stavanger and SINTEF (a company specializing in R & D).

As major oil companies shed R & D internally to cut costs, more R & D has been taken up by the service companies. This is not to say that major oil companies do not use or test new technologies; they do so in low-risk developments such as mature onshore operations. For the most part, however, the development and ownership of proprietary oilfield technology no longer lies with oil companies.There are some exceptions; the development of rotary-steerable systems to access complex well trajectories and expandable-casing for well construction was initiated by oil companies. NOCs are somewhat different as can be seen by Petrobras' R & D centre which has grown to support Petrobras' deepwater needs and has become a world leader in deepwater technologies. Norway and the UK have helped develop subsea technology and especially intelligent wells and real-time operations management. It should be noted, however, that the service side has played a crucial role in technology development in all cases.

Cluster Economies

It is recognised that the Arabian Peninsula's economies have been highly dependent on oil; it accounts for more than 75% of government revenues in the region. This made it crucial that the Peninsula diversify from oil dependence and open its markets to attract foreign capital. A good example of this is seen in Dubai which briefly had revenues in oil production but realised quickly that it could become a trading hub due to its location between Europe and the Far East and links within the Peninsula between Saudi Arabia, India and Iran.

Various initiatives were undertaken in Dubai; for convenience they can be classed as cluster economies. Dubai began experimenting with cluster economies through the development of Dubai Internet City in 2000. This has grown to house over 5,500 knowledge workers today, while Dubai's Media City houses most of the leading global media companies. Dubai's financial markets have also grown.

The opening up of Dubai's real estate sector has also helped diversification. Between 2004 and 2010, investments in Dubai's real estate sector are set at US $50 billion. This is serving to support Dubai's tourism industry as it aims to increase the numbers of foreign tourists.

Dubai first sought to consolidate the economy's major components of trade, transport, tourism and real estate sectors. It then moved on to promote aspects of a 'new economy': IT and multi-media activities and e-commerce and capital intensive, high-tech manufacturing and services (see Figure 16).

Rainy Day Fund

After an economic rollercoaster that saw Norway with the highest debt ratio ever attained by any developed country, the Norwegian Parliament established the Petroleum Fund in 1990. It receives net cash flow from the oil industry as well as profits from investments. The fund is designed to protect the economy should oil prices or activity in the mainland economy decline, and to help finance the needs of an increasingly elderly population and to cope with declining oil and gas revenues. The idea is to use 4% of the fund in the annual budget, but in reality larger transfers are made.

Too Much Local Content?

Government departments provided incentives enabling operators and the private oil sector to identify technology needs and fill them. This led to a trial and error system where technologies were not always applicable; however, it is not so important to focus on any single research program that did not work because with time a local knowledge base and competence was created.

The preferential policy may have gone too far in some cases, leading to an introverted mindset. For example, in Norway in 1990 at least 80% new prospect content was domestic. The advantages were jobs and profits in Norway, but there was far too much dependence on the petroleum industry for Norwegian manufacturing while exports to markets in other oil producing countries were limited.

Undoubtedly, this shows that the black blessing has improved lives within the space of a single generation and

Figure 12 and 13 - Old Stavanger Was Built On Fishing

Figure 14 - Modern day Stavanger, home of Norwegian Oilfeld Technology and the Norwegian FPSO

Figure 15 - Semi-Sub Platform

has led to the creation of new industries. There are many ways to make the blessing last. We have seen how global power has shifted from IOCs to NOCs and how many NOCs want to compete in international markets.

We have also seen the metamorphosis of certain IOCs into Energy companies. What drives this shift is a growing awareness that, above all else, holders of the reserves determine the rules. The next question then becomes clear – who actually holds the petroleum reserves? Are they globally dispersed or centralised in a few major locations?

References

1. Rice University's Baker Institute for Public Policy Oil production of the five largest oil companies has declined since the mid-1990s. Oil production for the five largest IOCs fell from 10.25 million barrels a day (b/d) in 1996 to 9.45 million b/d in 2005 before rebounding to 9.7 million d/b in 2006. By contrast, for the next 20 U.S. independent oil firms, their oil production has risen since 1996, from 1.55 million b/d in 1996 to about 2.13 million b/d in 2005 and 2006.

2. Little did Cardenas know what train of events he would set off.

3. Timeline OPEC: Origins & Strategy 1947–1973 Editor: A.L.P. Burdett.

4. "O petróleo é nosso" ("The oil is ours") was the battle cry vocalized by students and workers on the streets of Brazil during the '40s and '50s. On October 3, 1953, President Getúlio Vargas created Petróleo Brasileiro (Petrobrás), a

state monopoly in charge of E & P, refining and distributing oil in the country. See Offshore Engineer – Walks Tightrope, May 2003. See also Harts E & P Dec 2003 'Sustainable growth works' Interview with Petrobras E & P Director, Estrella.

5. The Prize: The epic quest for Oil, Money and Power Daniel Yergin Publisher: Simon and Schuster (Jan 01 1993), ISBN: 0671799320, Race begun.

6. Anthony Sampson The Seven Sisters: The great oil companies & the world they shaped.

7 The Prize: The epic quest for Oil, Money and Power Yergin Publisher: Simon and Schuster (Jan 01 1993) ISBN: 0671799320.

8 Oil and Politics in Latin America, Nationalist Movements and State Companies George Philip and Knight, Alan ISBN: 9780521030700.

9. Mexico's petroleum industry was taken back from the "Seven Sisters" in March 1938 by then-President Lazaro Cardenas, a revolutionary nationalist act.

10, 11, 12. F Parra, Oil Politics: A Modern History of Petroleum (IB Taurus, London 2004).

13. The Large International Firm in developing countries Allen and Unwin London 1968.

14. The late Professor Edith Penrose wrote in a book review in The Economic Journal in June 1963 (page 322): 'In the first place… the companies are truly international in outlook only to a limited extent; they are Western and their interests are firmly linked to those of Western Powers. Secondly, the people of the crude-oil producing countries do not believe that the companies act independently of governments and will not in fact absolve the "imperialist" powers from responsibility for company actions'.

15. See OPEC History.

16. Texas Railroad used by Tariki and Perez.

17. This is best displayed by modern NOCs such as Petrobras, CNPC and StatoilHydro.

18. Some commentators have ascribed various comments to Perez. No doubt whatever Perez said it would not have been polite.

19. See OPEC History 1st Resolution.

20. Anthony Sampson The Seven Sisters: The great oil companies & the world they shaped.

21. See Penrose and Sampson for rates of return for IOCs.

22. See Penrose The Unravelling of IOC concessions.

23. See OPEC recent history on website.

24. This remains the highest peaking of oil prices.

25. See OPEC recent history on website.

26. See Oxford Energy Comment, July 2000 Managing Hydrocarbon Resources in a New Era: The Call from Algeria, By Ali Aïssaoui for a modern viewpoint.

27. This was widely covered by the worldwide press.

28. See the Gas ventures in Saudi Arabia and the Service contracts in Mexico.

29. Refers to the US $147 peak in mid 2008.

30. OPEC is always widely covered by the press.

31. See EIA IEO 2008 reference case.

32. See Penrose on the IOC upper hand.

33. See commentary of BP in Iran 'its principality of production'.

34. Perrone, Nico Enrico Mattei, Bologna—Il Mulino, 2001.

35. Harts E & P Sept 2002 Drilling Column. 'Manage your tapped resources'. Discussion on industry cycles.

36. A decade ago the Oil price was US $10 bbl.

37. Cost reduction by Wajid Rasheed NWECS report summed by the Arco motto 'No decline in 1999'.

38. Cost reduction by Wajid Rasheed NORSOK NWECS report.

39. Financial Analysis of Mergers for shareholders.

40. See Rice University's Baker Institute for Public Policy Exploration spending of the five largest IOCs has been flat or lower in the aftermath of OPEC's reinvigorated effort to constrain market supply in 1998. Given the uptick in costs of material, personnel and equipment such as drilling rigs, the five largest IOCs have cut spending levels in real terms over the past 10 years. This trend appears, however, to be easing, with exploration spending by the five increasing IOCs rising by 50 percent in 2006 over 2005.

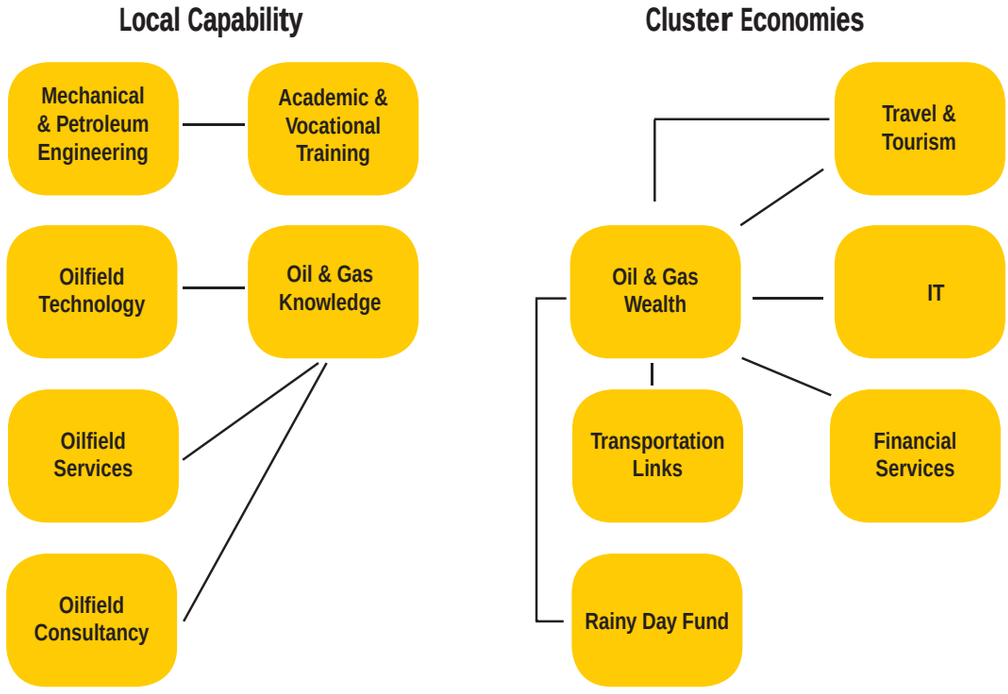


Figure 16 - Relationship of Oil and Gas in Economic Sustainability (EPRasheed)

Instead of favouring exploration, the five largest IOCs used 56 percent of their increased operating cash flow in 2006 on share repurchases and dividends. They have also increased spending on developed resources, presumably to realise these assets quickly while oil prices are high.

41. See Harts E & P Dec 2003 'Sustainable growth works' Interview with Petrobras E & P Director, Estrella.

42. See In the Shadow of a Saint, by journalist Ken Wiwa for an alternate viewpoint on the Niger Delta.

43. Corporate governance equally applies for individuals. Being hired by any service or oil company involves numerous due diligence and non-conflict forms.

44. The international aspect really applies to the NOCs that have high cost reserves. Rice University's Baker Institute for Public Policy Wall Street investors increasingly recognize these new exploration investment trends and the value of shares of NOCs have risen at a much faster rate than those of the largest IOCs.

45. Norway Oil and Gas Issue 1 (www.norwayoilandgas.com).

46. See Saudi Aramco Annual Report 2006 Rabigh.

47. Idem.

48. Idem.

49. PdVSA Annual Report 2006.

50. See PdVSA Annual Report 2006 Petro Caribe.

51. PdVSA Annual Report 2006.

52. Harts E & P Dec 2003 'Sustainable growth works' Interview with Petrobras E & P Director, Estrella.

53. Petrobras and Self-sufficiency The Zero fome campaign was widely by the Brazilian press.

54. Brazil Oil and Gas Issue 4 interview with Petrobras USA President Renato Bertani.

55. Idem.

56. USA President Renato Bertani Monolithic Offshore Engineer, by Wajid Rasheed.

57 Norway Oil and Gas (www.norwayoilandgas.com)

58. See Penrose.

59. The Harts E & P Mar 2002 Drilling Column. 'Small companies and tangled thickets'.

60. Black Blessing—Saudi Arabia Oil and Gas Issue 5. See Author's Interview with OPEC, Chatham House, The Royal Institute of International Affairs, NPD Norwegian Petroleum Directorate. Dubai Media City.

age.

Existe uma área para a sua empresa atuar que pode gerar grandes oportunidades. E ela tem 149 milhões de km².

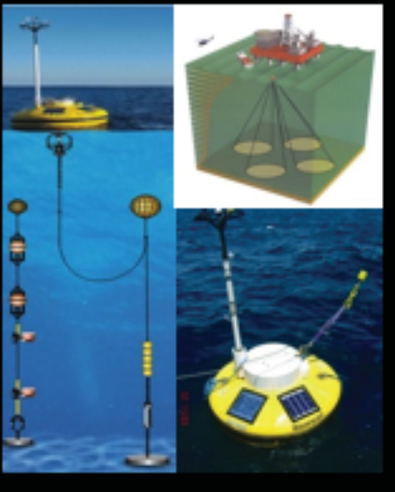
A exploração de gás e petróleo da camada pré-sal começa apenas em 2010. Mas a sua empresa já pode se preparar para as oportunidades que o mercado vai oferecer. E, para isso, ela precisa dos melhores parceiros: o Oil & Gas Group da PwC é referência em serviços de consultoria empresarial na área e possui um network global de especialistas. Se você busca suporte e segurança para aproveitar as oportunidades do pré-sal, fale com a PwC.

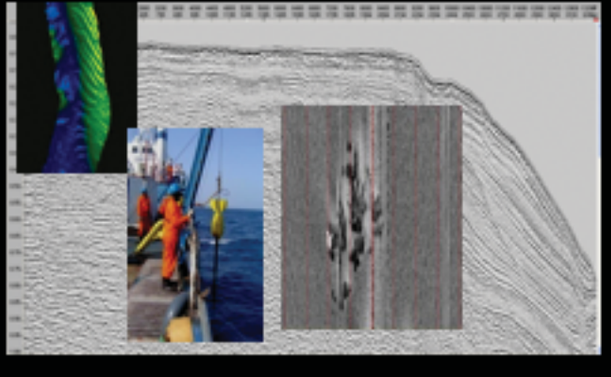
pwc.com/br

PRICEWATERHOUSECOOPERS

Data acquisition, offshore and consulting services? ..... **Ask FUGRO.**

- ROV services (IRM, Drill support, tooling)
- Diving services (air and saturation)
- Survey - Pre-drilling Hazard/Geophysics/Geology/Geochemistry (single/multibeam bathymetry, side-scan-sonar, sub-bottom-profiler, magnetometry, piston coring)
- Rig/vessel positioning and construction suppport
- Acquisition, processing and analysis of metocean data (fixed station, mooring, buoy)
- Environmental studies, satellite data analysis and oil spill/cuttings modelling





Fugro Brasil – Serviços Submarinos e Levantamentos Ltda
Rua Santa Luzia, 651, 32° andar - Rio de Janeiro, RJ - 20030-041 – Brasil
Tel: (+55) 21-21258500 Fax: (+55) 21-21258501
Email: fugro@fugro-br.com - Web: www.fugro-br.com

NO OTHER COMPANY IN BRAZIL CAN OFFER THE SAME RANGE OF INTEGRATED SERVICES