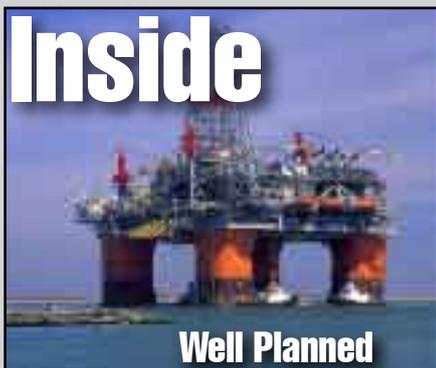


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**2007 - Issue 1**

# Saudi Arabia oil & gas

**Inside**



**Well Planned**



**EP in Rub Al Khali**



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Rig at night in Rub Al Khali  
Photo: Courtesy of Saudi Aramco

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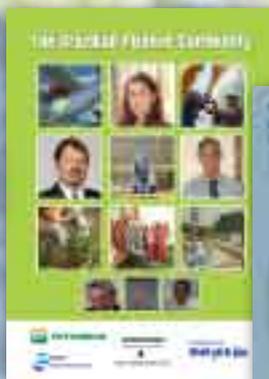
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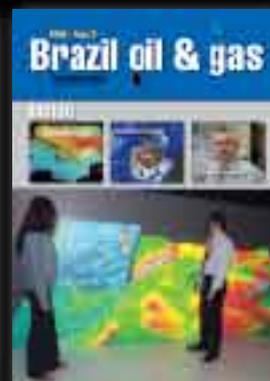
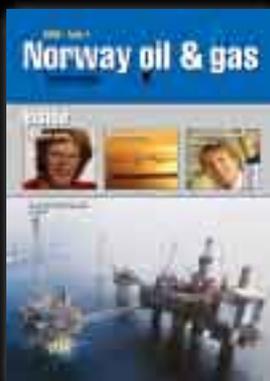


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2007 – Issue 1

# Saudi Arabia Oil and Gas

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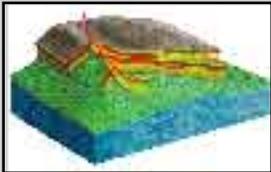
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# NOTE FROM THE CEO

On behalf of EPRasheed's Signature Series, I am pleased to pen this brief introduction to our exciting and newest publication Saudi Arabia Oil and Gas.

EPRasheed is an innovative Oil and Gas publisher that has a truly international and diverse workforce that hail from all over the world. It is the only Oilfield publisher that operates worldwide much as an International Oil Company or as a Multi-national service company.

## National Oil Company Focus

Founded in 2004 by Wajid Rasheed, EPRasheed focuses on select National Oil Companies and EP technologies worldwide (see [www.eprasheed.com](http://www.eprasheed.com)). Some of these markets are Brazil, Norway, Saudi Arabia and Trinidad and Tobago.

Although the NOC hold reserves, technology, project management skills and capital – this is not reflected in the industry press. The problem stems from the historic base and focus of the industry press toward Northern Europe and North America. In some ways, this is a legacy of the 80's and 90's mega-mergers and cost-cutting with many IOC, service co's and much of the oilfield press consolidating in Houston.

Our aim is to consider global EP Markets in a strategic manner and foster balanced coverage and commentary on International Oil and Gas markets and key EP technologies.

## EPRasheed Signature Series

We are the first oilfield publication to think like a service company – ie to look strategically at global EP markets and invest time and money in developing innovative products and pioneering projects.

The EPRasheed Signature Series has taken shape, over the past 3 years we have interviewed over 100 senior execs

ie Petrobras President Jose Sergio Gabrielli, Statoil (US) President Oyvind Reinertsen, Lisbeth Berge Permanent Secretary Norway Petroleum Ministry and countless technology, corporate and operations managers.

## Saudi Arabia Oil and Gas - Technology

In the case of Saudi Arabia Oil and Gas – we see EP Technology as a foundation of certainty of supply and countering the doomsayers. The doomsayers do not have a geological (carbonate reservoirs) or drilling (geosteering) or completions (minimizing reservoir damage) background.

But they are good marketers.

Technology is key to dispelling the historically recurrent Peak Oil claim. Technology is a basis for calming markets as it continually enables new reserves to be found and produced. Therefore, our interest lies in technology at all stages of its application. From solving well, field and asset challenges to laboratory R&D projects to run data and applications analysis.

If we consider how countries such as Norway and Brazil have reached production in incredible conditions – complex subsea tie-ins and floating production systems in Arctic and Ultra-deepwater plays, we see the previously unthinkable as a revenue generating deliverable. In other words, a bottom line benefit. Imagine how much more can be done for less harsh environments such as Saudi Arabia?

We look forward to your comments – ultimately our readers' guidance will help make Saudi Arabia Oil and Gas a success.

So don't be shy - write to [wajid.rasheed@eprasheed.com](mailto:wajid.rasheed@eprasheed.com).

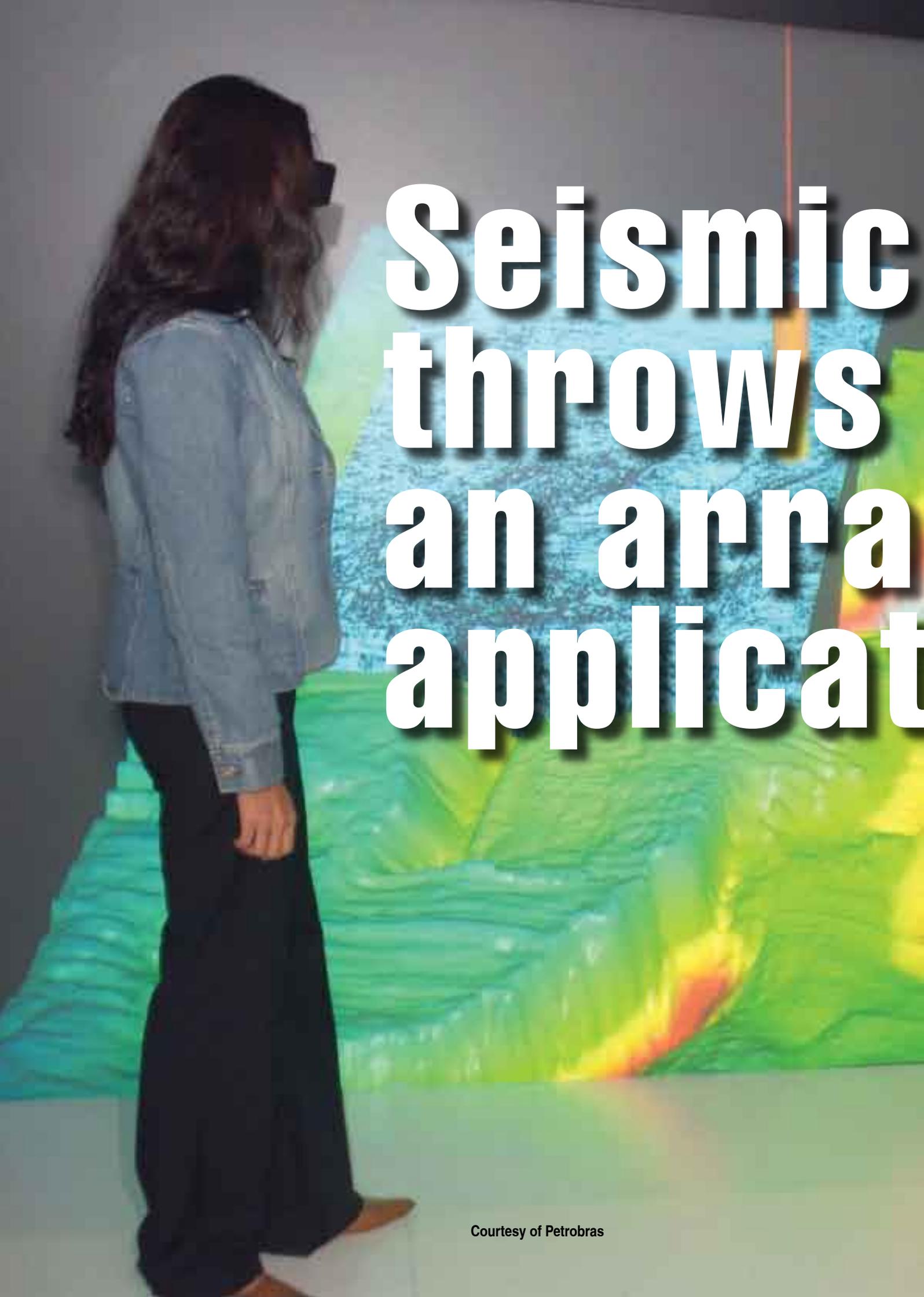
Enjoy the magazine.

**"Our aim is to consider global EP Markets in a strategic manner and foster balanced coverage and commentary on the International Oilfield and key EP technologies." Wajid Rasheed**

Founder EPRasheed and Saudi Arabia Oil and Gas

*W Rasheed*





# Seismic throws an array of applications

Courtesy of Petrobras

# up y of ions



**Recognized as a key oilfield technology, Seismic has made a tremendous contribution to EP by adding reserves and improving production.**

**This article looks at the major seismic technologies that service and oil companies are betting on in the race to find and produce reserves.**

By Wajid Rasheed

Greater well placement accuracy, better reservoir characterization and enhanced production curves are just some of the offerings of seismic. Traditionally, seismic has always been synonymous with greenfield or exploratory development. However, it has successfully branched out to brownfield or mature applications. It has now become a tool that accompanies the life-cycle of the asset providing value in prospect selection, reducing drilling risk and maximizing production at all stages of recovery.

Driven by various operational and geophysical obstacles worldwide, seismic technology has thrown up an array of applications that include the imaging of deepwater subsalt migration and plays, the drilling of more 'wet' holes, Vertical Seismic Profiling, Electro-magnetic seismic, 4D time-lapse seismic and Passive seismic.

### **Sub-salt seismic**

Increasingly oil companies are moving out to deep and ultra deepwater frontier locations and greater emphasis

is placed on characterizing deep subsalt reservoirs. The prize is to access reservoirs and maximize production but there are many obstacles. One of which is, for example, massive salt sections in deepwater acreage that complicates seismic acquisition and imaging. These are frontier areas characterized by expensive wildcats that hold very high hydrocarbon bearing potential. In terms of plays this can be seen with a series of sub-salt finds in the US GoM, for Brazil and Angola. However, massive salt sections can block or attenuate seismic, making the extraction of field data more difficult.

Approximately 15 years ago, the industry started to overcome the depth penetration issues and subsalt attenuation limitations. In those days, 2 Dimensional seismic technology (2D) could often only locate 'shallow plays'. In contrast, today's multi-component 3 and 4D seismic can help resolve the problems of poor acquisition and attenuation due to massive salt sections and locate deeper reservoirs below mature fields or salt sections which were previously uncharacterized. Exemplifying

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

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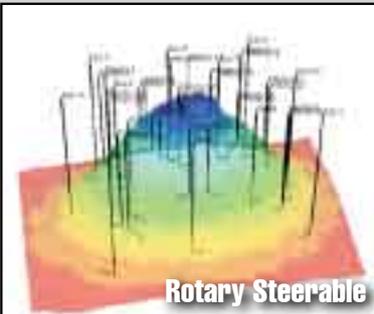


**2007 - Issue 7**  
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**Inside**

- Open Market privatized
- Initial low royalties
- Higher royalties with finds
- Local content requirements
- Local capabilities
- Nationalization The oil is ours
- Certain Foreign Operators
- Firm Privatization New contracts
- Oil Industry has come full circle.

**Bids & Blocks**



Time lapse or 4D seismic accompanies the lifecycle of an oil and gas asset providing valuable seismic information on the asset as it matures. This can generate tremendous value in shaping decisions as to the peaking of production rates, decline curves and secondary recovery techniques.

this are the new deep gas plays being explored in the Gulf of Mexico (both Mexican and US waters) and Offshore Eastern Brazil. Deeper reservoirs or those located below salt would have been overlooked as previously seismic was not capable of penetrating beneath shallow reservoirs or below formations containing thick layers of salt. Hand in hand with seismic advances have been drilling technology firsts such as overcoming directional control and drilling torque problems of drilling 10km depths.

Such deeper prospects combined with subsalt are increasing demand for long offset data. The basic principle is that the longer the offset between the source and the receiver, the deeper the survey. Here all parties involved must pay careful attention to environmental controls to minimize any impact and work within distance limits. For deeper or sub-salt seismic, two seismic vessels are run together with both shooting simultaneously and using long streamers. Global Positioning Systems are used to keep the two vessels at a known distance and this maintains the required distance between the source and streamer to accurately measure seismic reflections from deep and sub-salt formations.

### **Seismic imaging helps drill more 'wet'-holes**

Seismic multi-component 3 and 4D technologies along with better seismic imaging helps drill more 'wet'-holes because it provides greater precision of the location and

migration of hydrocarbons. It has been shown that with the availability of timely information, accurate reservoir models can be constructed, and smart, controllable wells can be planned. Multi component acquisition involves larger volumes of data but it also enables the direct detection of hydrocarbons as well as reservoir geometries.

Reservoir monitoring begins with a baseline survey, preferably acquired before any production of hydrocarbons has begun. A monitor survey is later acquired after production has begun, and a physical change in the reservoir state has occurred. Successive monitor surveys are then acquired throughout the lifetime of reservoir production.

### **4D seismic**

Time lapse or 4D seismic accompanies the lifecycle of an oil and gas asset providing valuable seismic information on the asset as it matures. This can generate tremendous value in shaping decisions as to the peaking of production rates, decline curves and secondary recovery techniques. Usually, a cost – benefit analysis is conducted which measures costs and attributes the value gained. This exercise can be difficult as the value gained may often be indirect. 4D seismic is mainly used to better manage reservoir production across the lifecycle of a field. Due to the increasing number of brown fields worldwide applications of 4D seismic have increased substantially. However, as 4D seismic is a recent technology there are

Oil companies are developing passive seismic where there is no man-made source. The source consists of harnessing naturally occurring sounds, of which there are two types – the first are micro-seismic events and the other is injecting CO<sub>2</sub> gas, which is registered at surface. The origin of the source is not well established but is thought to be tidal based.

relatively few processes available to evaluate it. This has allowed us to image ‘harder to see’ reservoirs such as thin layers which can be missed by conventional seismic. With 4D time based seismic it is also possible to view migration as two time - lagged surveys, say a year apart, to show how hydrocarbons have moved.

### **Vertical Seismic Profiling (VSP)**

VSP aids exploratory and development drilling by reducing risk and uncertainty. In this way, seismic has evolved from being an exploratory risk - mitigating tool to a reservoir management tool with applications in mature fields. Offshore, the trend is for the installation of permanent seabed cables. These provide a lifecycle perspective by taking repeat shots, overlaps and using permanent cables that use fibre-optics. This is because shear waves do not travel through water and therefore require seabed and solid media. However the cost of VSP Multi Component data can be typically double the cost of regular P wave or marine.

### **Electro magnetic surveys**

Magnetic seabed logging using controlled source electronic mechanism (CSEM) is another emerging area of interest. Here the focus is on interpreting and visualizing data as seabed logging allows physical qualities to be mapped with high resolution. An artificial electro-magnetic source is used on the seabed in conjunction with recording instruments that register resultant magnetic fields. A low frequency signal is emitted by

the source, which penetrates formations to a given depth. The CSEM system is useful because it can help differentiate between hydrocarbons and water. This is because the CSEM propagates more effectively and is subject to less attenuation in higher resistivity layers which are precisely formations of interest; hydrocarbon bearing. Seabed logging allows the physical qualities to be mapped in those areas with high resistivity allowing the accurate delineation of reservoirs. Although this is an auxiliary technique it offers great value in deep and ultra deep water applications. The key is its combined use with wider seismic which enables better characterization and hence a better return on investment for exploratory and delineation projects.

### **Passive Seismic**

Oil companies are developing passive seismic where there is no man-made source. The source consists of harnessing naturally occurring sounds, of which there are two types – the first are micro-seismic events and the other is injecting CO<sub>2</sub> gas, which is registered at surface. The origin of the source is not well established but is thought to be tidal based.

In all these applications and others, Seismic plays a special role in reducing oil and gas EP risk. There are not many technologies that have such a broad range of oilfield uses – seismic is one of them.

*Acknowledgements: Calvert, 2005; Faria 2006; Long PGS, 2006 and Rasheed, 2006.*



By Muhammad M. Al-Saggaf, Ph.D. (Exploration) and Mohammad Y. Al Qahtani, Ph.D. (Development) of Saudi Aramco

### Exploration through innovation

Seismic surveys have become the most common and widely used method for studying earth layers. Today, sophisticated oil exploration technologies use devices that operate on principles similar to those of earthquake measuring scales, i.e., seismographs to measure and record lower frequencies of ground vibrations or man made shocks produced by blasting explosive charges in a series of small depth holes to generate vibration waves.

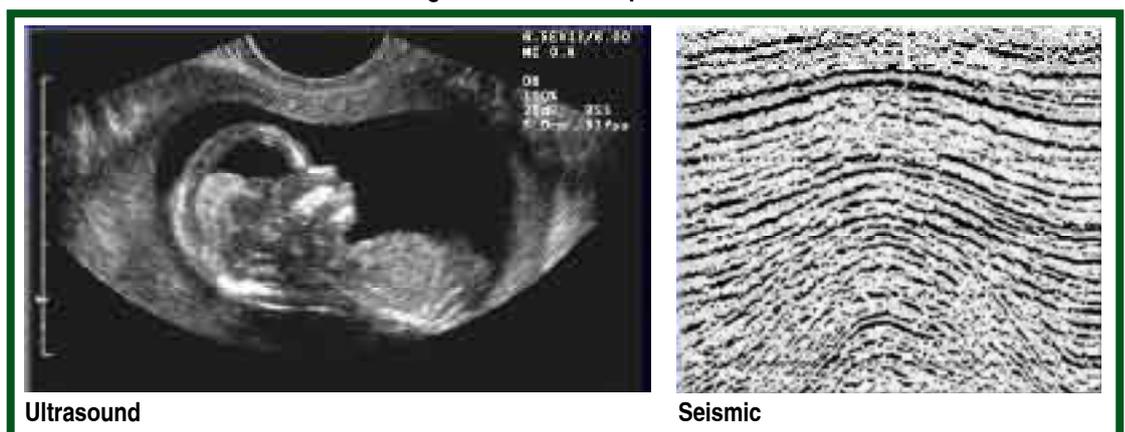
Many of us are familiar with ultrasound pictures known as sonograms. These images are built by sending sound waves into the human body and recording their reflections, i.e. to see a baby before it is born. The objective of seismic data is quite similar; not to image the belly of a human being but rather to image the belly of the earth. Information in respect of sub-surface structures, before we drill, is gained by having sonograms of the earth and by using sound waves as well.

One of the most difficult challenges facing Saudi Aramco's

seismic interpreting efforts is the problem of land interbed multiples. When you shout in a big room, you hear repeated echoes of your voice. Similarly, in addition to the primary energy reflected from the subsurface, repeated echoes are generated when the energy reverberates between strong subsurface reflectors. This gives rise to ghost reflections, or multiples. These do not represent real structures and they must, therefore, be removed from the seismic data.

In collaboration with international academia Saudi Aramco are using a new technique to predict and remove these multiples. The multiples are greatly attenuated, leaving the section much cleaner, much easier to interpret and to make use of – showing true, rather than false, structures.

Figure 1 - Seismic Exploration

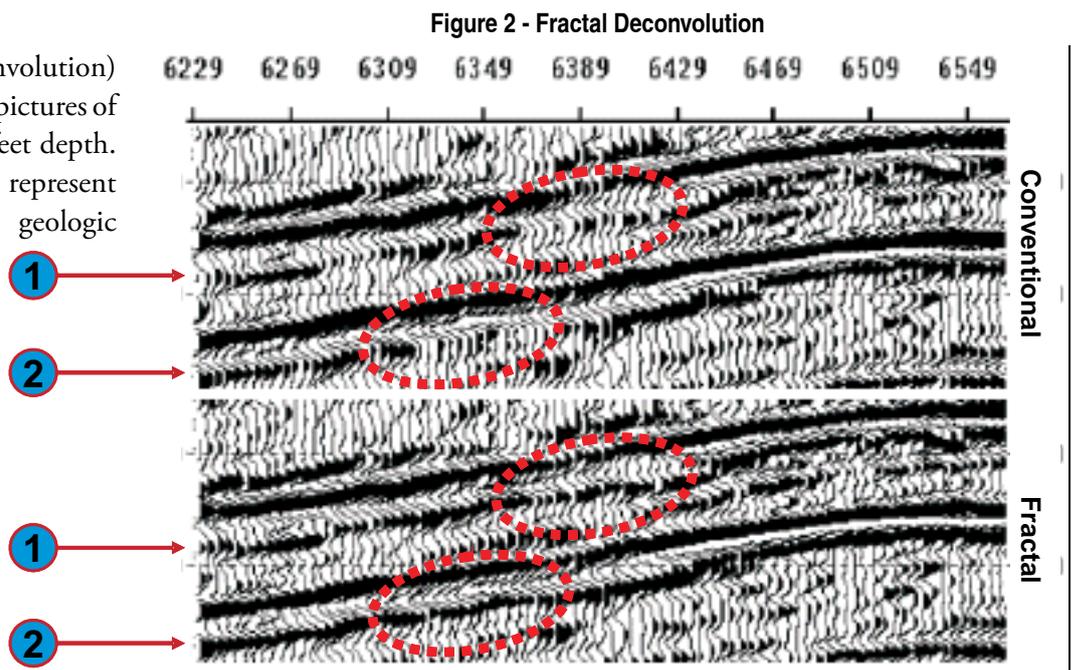


# TECHNOLOGIES

## THE WAY FOR A BRIGHTER FUTURE

**Saudi Aramco have been exploring and developing the vast resources of the Kingdom of Saudi Arabia for over 70 years. Technology plays an important role in its success, coupled with resource potential, people and best practices. This article focuses on some of the technologies Saudi Aramco have developed in-house to tackle the challenges that are faced.**

Figure 2 (Fractal Deconvolution) displays seismic sections – pictures of the subsurface at 10,000 feet depth. The white and dark areas represent different layers and geologic formations. Processing seismic data is important to improve the clarity of these pictures and one of the fundamental steps of seismic data processing is fractal deconvolution. It is akin to developing photo film, to add focus and enhance the resolution.



Remember, seismic data is all about pictures. Saudi Aramco have developed a new deconvolution algorithm, called fractal deconvolution that yields more accurate seismic data. The top seismic section was processed by the conventional method. Several breaks can be seen in the data because of the lack of focus and resolution. The lower section was processed with Saudi Aramco's new method, which improves the focus and resolution thus allowing a better view into the subsurface. Having better pictures of the subsurface can enhance the success in looking for hydrocarbon resources.

One of Saudi Aramco's objectives is to be able to identify the quality of the reservoir before drilling, just like seeing the baby before it is born. For example, ascertaining the locations of sub-surface channels and targeting them, because they hold rocks of the best reservoir quality. These channels are not migration paths – they are pay zones within the reservoir – and they are quite deep, about 14,000 feet below the surface.

Coherence analysis detects these channels, and Saudi Aramco have developed a new algorithm for computing coherence, based on the generalized Hilbert transform,

and implemented in a tool called DETECT. This yields more accurate images of the subsurface channels, when compared to conventional methods.

Figure 3 (Reservoir Thickness Estimation) was produced by DETECT, as opposed to a commercial package, and this results in clearer channels and a picture that is much more lucid.

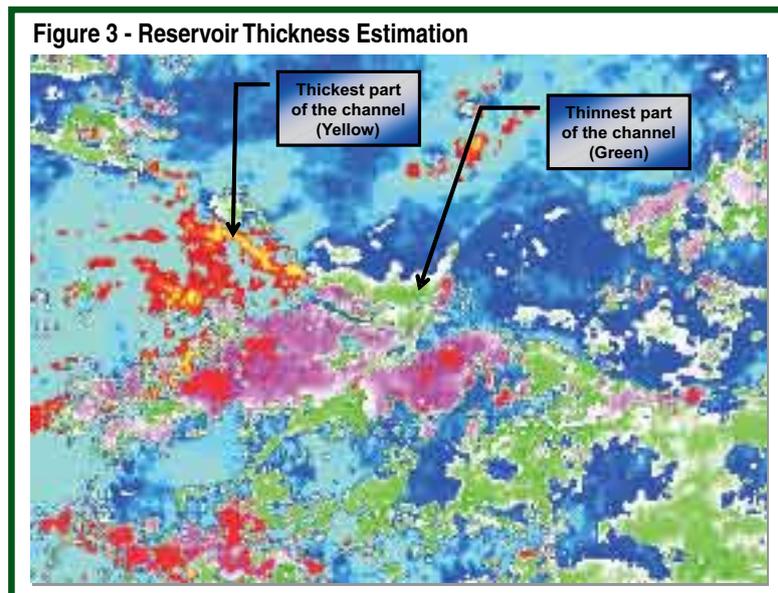
There is not only interest in detecting the channel locations, but in estimating their thickness as well. The thicker the channel, the bigger the payday is. Saudi Aramco have also developed a new algorithm based on analyzing the variability of the frequency content of seismic data. This can estimate the channel thickness and produce images that depict not only the locations of subsurface channels, but also their thickness. This way the thickest portions of the channels can be targeted and well productivity can be maximized.

The human brain has about 50 billion small cells called neurons, which are interconnected by synapses to form neural networks through which electrical signals flow. It is through the flow of electric signals and the activation of these neurons that we get our capacity of perception, learning, thinking and behavior.

Artificial neural networks simulate biological ones with the objective of replicating the human ability to perform pattern matching, pattern identification, and information extraction. Saudi Aramco utilize neural networks to extract porosity information from seismic data. (In a nutshell, porosity is a measure of how much void space the rock has, how sponge-like the rock is, and therefore how much hydrocarbons it can hold. The higher the porosity, the better the reservoir).

Saudi Aramco utilize neural networks to extract porosity information from seismic data and build porosity models of the reservoir that are then sent to engineers to complete a reservoir simulation. Saudi Aramco's contribution was in the development of a new type of neural network, called regularized neural networks, which are much more accurate than the conventional ones.

In fact, the application in Shedgum managed to attain a 22% improvement in the accuracy of predicting the reservoir porosity from seismic data over the conventional neural networks. This allows Saudi Aramco to obtain more accurate estimates of oil and gas volumes and to predict the productivity of their wells before drilling to a much better extent and therefore optimize well placement and reduce risk.



### Integrated approach

Two recent discoveries provide excellent examples. In Duaiban and Midrikah, Saudi Aramco used these tools in an integrated manner, coupling several of them together, to tackle this non-conventional stratigraphic pinch-out play and locate Duaiban-1 and Midrikah-1, respectively.

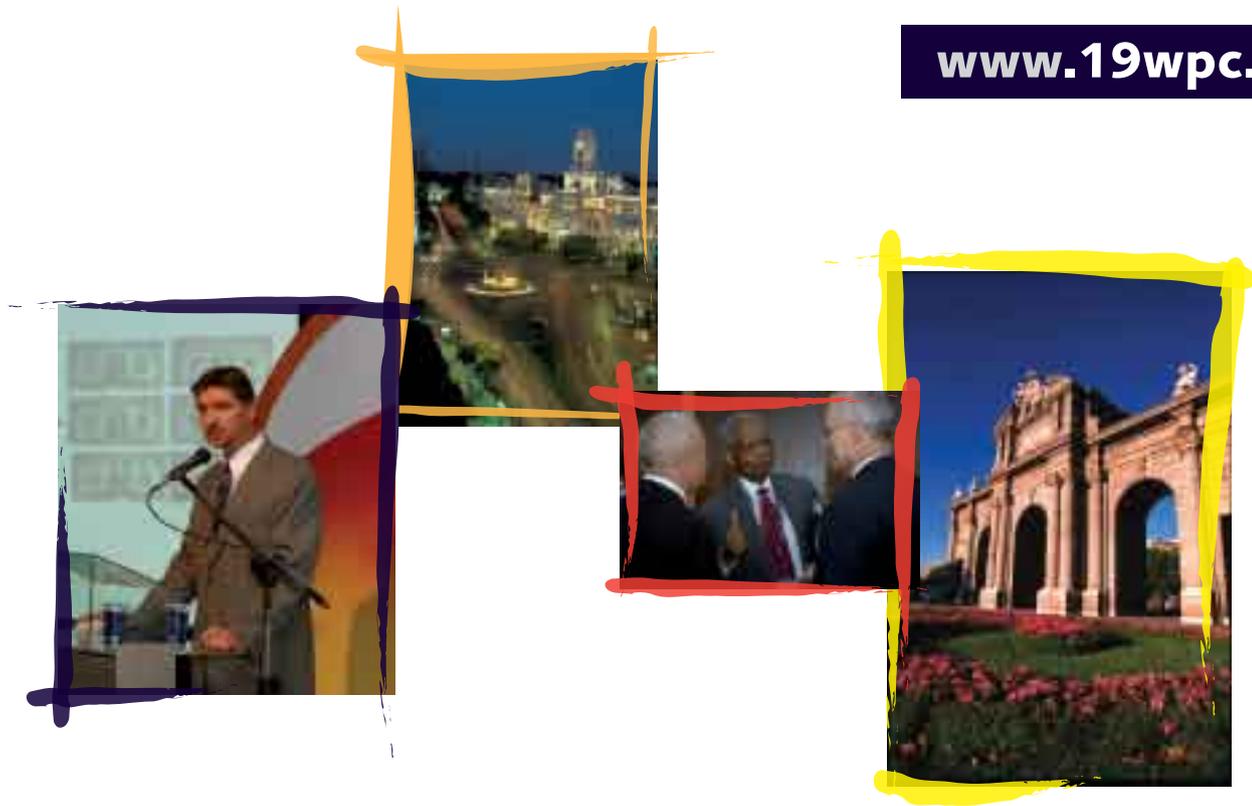
These tools were also used to locate Karan-6, which was finished drilling in May offshore in the Arabian Gulf and was the discovery well for the Karan gas field. This field has a substantial upward potential, as its currently mapped structural closure extends over 30 km in length (20 miles), or over 400 square km in area.

Combining Saudi Aramco's resource potential, people, technology and management tenets has made them successful in the gas program. They are now focusing on the oil and a resource potential that is much more immense than their gas potential.

### Development to meet global demand

A key supply strategy of the company, which distinguishes it from most other producers, is to maintain a spare production capacity of 1.5 to 2 million barrels per day. As production increases, Saudi Aramco are steadily developing new fields and expanding the capacity of existing ones, to maintain the spare production capacity. By the end of 2009, Saudi Aramco will have a maximum sustainable capacity of 12 million barrels per day, compared to 10 million barrels per day in 2004.

Their strategy for ensuring the success of this plan entails four essential pillars: a large reserve base, the appropriate application of technology, qualified and well-trained human resources capable of implementing these technologies and the ever-increasing complexity of



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operations and, most importantly, the body of knowledge, mechanisms, and processes referred to as management tenets. This ensures best practices and proper governance of their fields and reservoirs.

The high impact technologies covered by this article are Advanced and Smart Wells, Reservoir Diagnostics and Modeling and the I-Field concept.

The first technology example, proving to be highly value-additive, is Geosteering. It is a key enabler in achieving the impressive sub-surface statistics required in many of Saudi Aramco's horizontal and maximum reservoir contact wells to increase well rate and improve recovery.

The ability to place wells with complex architectures within a tolerance of a few feet, thousands of feet underground, requires extreme precision and multi-disciplinary coordination among earth scientists and engineers, as well as rig crews.

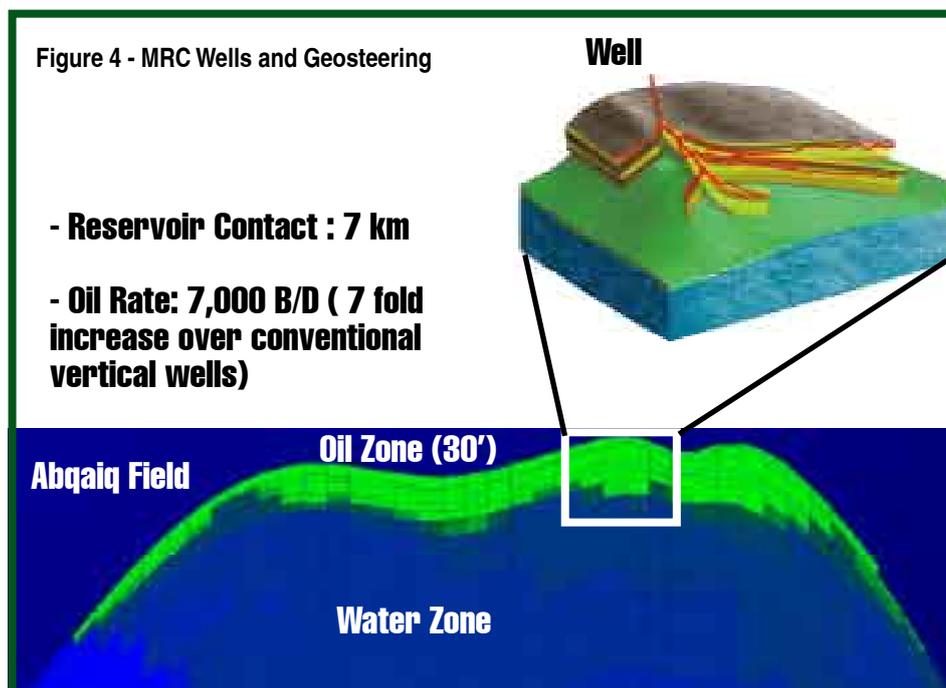
One well illustrates the benefits of Maximum Reservoir Contact (MRC) and Geosteering technology in the mature areas of the Abqaiq field, targeting thin oil columns in the order of 30' as illustrated in Figure 4 (MRC Wells and Geosteering). Actually, their target well placement is in the top 10' of these zones. The geosteering capability

ensured that they place the well precisely in the target interval with over 7 km of reservoir contact, avoiding the water zone just below it. The well achieved 7,000 barrels per day of oil, which is a seven fold increase compared with nearby conventional vertical wells.

Advanced Geosteering tools coupled with real time modeling, have helped them navigate the well path, just like radar, alerting them to any potentially undesirable nearby water zone or reservoir boundary. Geosteering has increased their horizontal drilling efficiency by 50% over the last 3 years, translating into a substantial gain in oil rate.

The Abqaiq field is Saudi Aramco's most mature asset and has been in production since 1948. Today, it is producing at 400,000 barrels per day with a water-cut of less than 40%.

In the Arab-D, which is the principal reservoir, they have already produced 55% of the oil initially in place and are currently projecting recoveries in excess of 70%, solely by water-flooding and without the benefit of enhanced oil recovery (EOR) techniques. It is worth mentioning that the booked reserves are only 65% of oil initially in place (OIIP), which underscores the conservative approach Saudi Aramco take towards reserves.



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They are projecting an expected ultimate recovery from Abqaiq of approximately 80%, using EOR and other technologies. The performance of Abqaiq and other fields is not coincidental but rather a reflection of their management tenets employing the optimum technology where applicable.

Reservoir Modeling and Simulation is one of the most important tools for conducting proper diagnostics and forecasting. In response to the simulation requirements of their giant reservoirs, Saudi Aramco has developed a reservoir simulator called POWERS™ (Parallel Oil Water Reservoir Simulator). See Figure 5 (POWERS Simulation Technology).

POWERS simulation capability has shown continuous and significant increases over the last decade. As an example, POWERS is capable of running over 17 million-cell simulation models for the Shaybah Field in a few hours — an accomplishment that was inconceivable a few years ago.

Saudi Aramco is currently developing the next generation of POWERS, called POWERS-2, capable of running simulation models in excess of 100 million cells by 2008. POWERS' superior simulation technology allows more accurate predictions of field performance and advanced

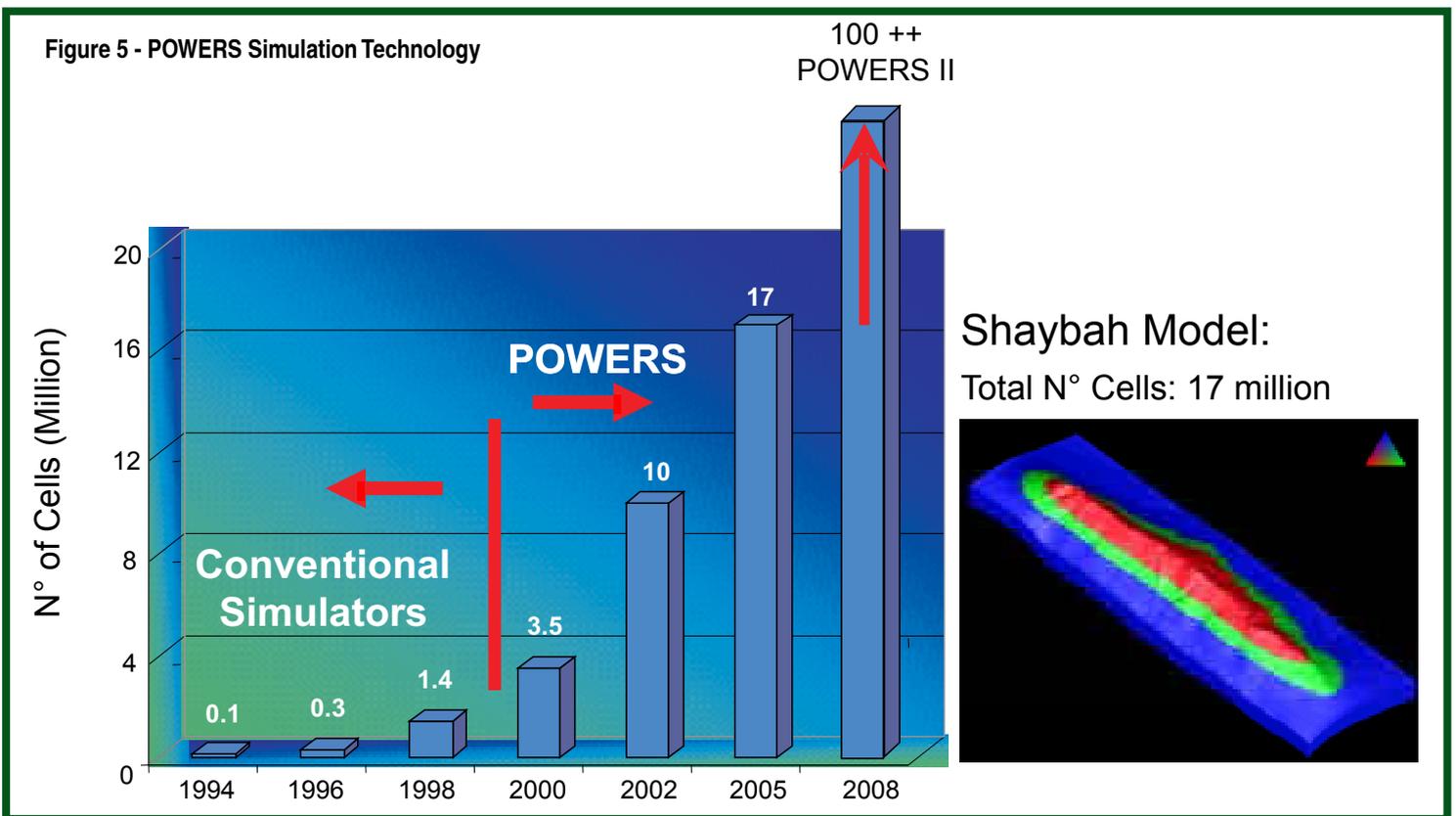
diagnostics, enabling Saudi Aramco to implement the most optimum field development.

The I-Field concept is defined as the integrated real-time access of critical subsurface and surface data to achieve higher levels of optimization in field management.

In the I-Field concept, most of the wells are equipped with sub-surface and surface sensors and controls, which can transmit measurements of pressure; temperature; oil, gas and water rates in real-time to their data centres and asset teams. At the same time, full and real time control on fluid flow is possible. This capability in turn can be incredibly powerful in better managing their fields.

Saudi Aramco realize that the journey ahead in the I-Field domain is not straightforward. There are large obstacles to be overcome as an industry. Yet, they have taken a very important leap forward in this area with the successful implementation of this concept in the Haradh Increment-3 just completed early this year.

Haradh is part of the super giant Ghawar Field and about 75 km long and 26 km at its widest point. The initial oil-in-place is approximately 38 BSTB corresponding to reserves of approximately 19 BSTB. To date, they have produced 2 billion barrels.



“We are entering a new age and see a bright future for E&P through the introduction of innovative technology, which will provide significant upside potential in increasing reserves as a result of improved recoveries.”

It is worth mentioning that the reservoir properties in Ghawar change from north to south. For this reason, the development of Haradh presented a number of reservoir related challenges, including lower rock permeability and multi-scale heterogeneities including faults and fractures.

For development purposes, Haradh was divided into three equally sized increments. Haradh Increment-1 was the first to be developed. It was placed on-stream at 300,000 B/D during the second quarter of 1996 and developed using vertical wells. The Haradh Increment-2, which came on-stream during the second quarter of 2003 at a rate of 300,000 B/D, was developed exclusively using horizontal wells. At the time, horizontal well technology was considered a “game changer.”

Haradh Increment-3 was placed on-stream three months ago and is being developed using an exclusive number of new “game changers”. This includes MRC wells, Smart Completions, and implementing the I-Field concept.

On equal basis and on average, Haradh Increment-3 wells are designed to deliver two and a half times the production rate of Increment -2 horizontal completions, and five times the production rate of Increment-1 vertical completions, while offering improved subsurface configurations for better sweep. This has translated into substantial reduction in well requirements.

A Real-time Reservoir Management image is an animated pressure map of all pressure data gathered, like the injection campaign in the Haradh Increment-3, prior to startup.

Just like an animated weather map tracking an event, this data is extremely useful in determining the optimal injection and production levels of individual wells and

regions. The result is real time reservoir monitoring and intervention to manage the field in the most optimum manner.

Let’s take a look at a prediction of field response using state-of-the-art reservoir simulation and modeling techniques.

The prediction was run for 50 years and what has transpired is how effective the sweep efficiency is in Haradh Increment-3 using MRC wells with smart completion. The technologies used are predicted to achieve excellent sweep and thus longer plateau life, lower water production and ultimately improved recovery.

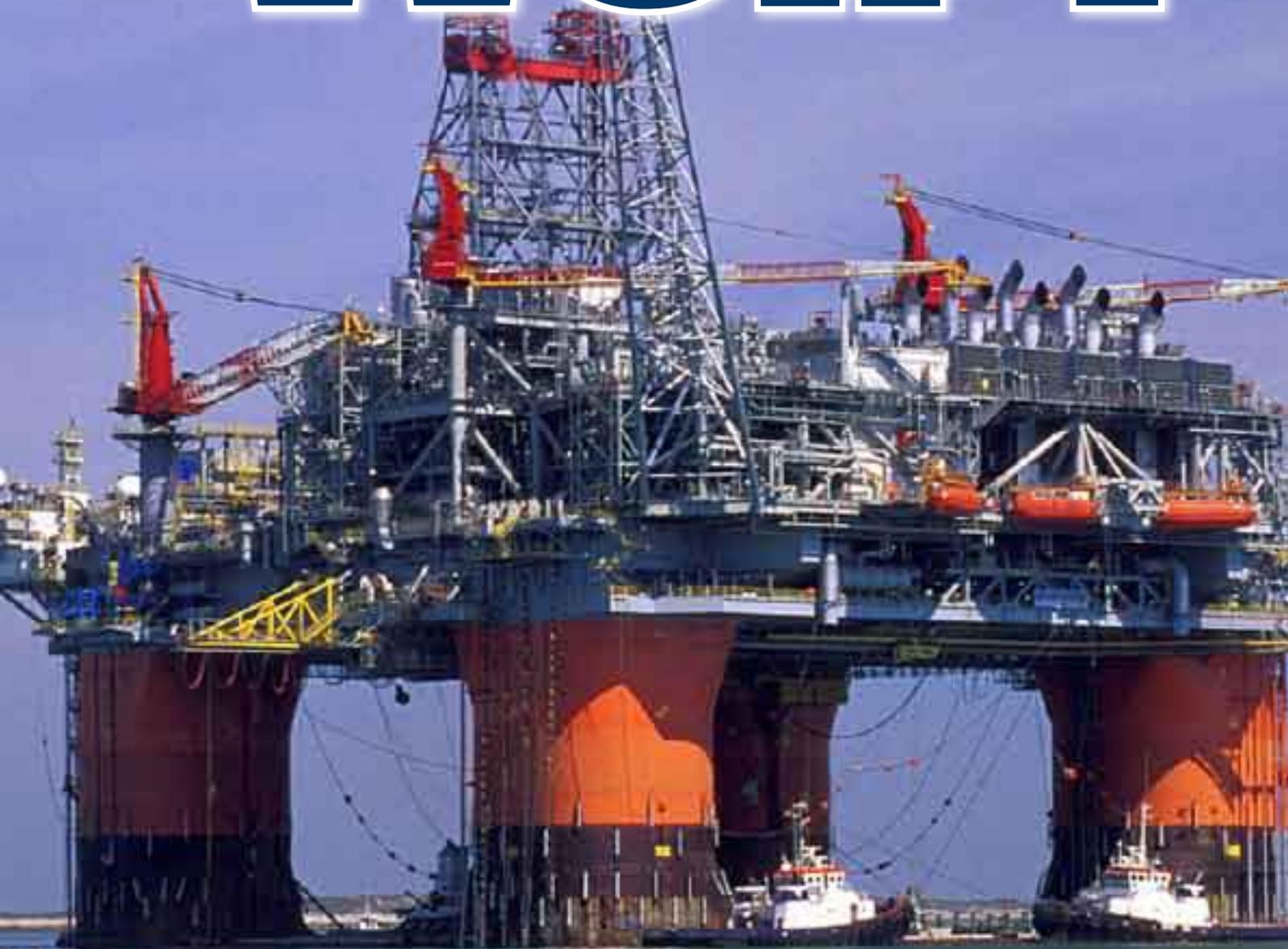
Through their commitment to unique Management Tenets in developing and producing their fields, and the application of high impact technologies, Saudi Aramco has been able to control the increase in water cut for the sixth consecutive year. This is considered an outstanding performance by industry norms. So far and to date, the trend is continuing and poised for yet another year of excellence.

### The future

The results are positive, in terms of their impact: lower development and operating costs, increased recoveries and extended production plateaus.

The examples covered encapsulate, in many ways, the future of exploration and production across the industry. These technologies have given Saudi Aramco a preview of what lays ahead. Real-time capture of information, more effective water management and smarter and proactive reservoir management are here to stay with us. 

# Well P



# Planned

**Well planning is the process of creating a blueprint for constructing oil and gas wells. This article takes a behind the scenes look at the key components of well planning and their interaction.**

By Wajid Rasheed

**T**he Well Plan – a book-like bundle of engineering and legal documents – covers all aspects of designing, drilling and completing a given oil and gas well.

Large operators may refer to this as the ‘pre-drill package’ (purists may argue about the exact usage of terms but they both refer to the same thing). Smaller oil companies will simply refer to the documents as the well plan. This should be distinguished from the well profile which only describes the proposed architecture and sizes of the well. We have already seen how raw seismic info is processed into geological data. After, poring over this data bright spots and prospects are identified.

However, a prospect must be converted into a well-plan. Prospects are oil and gas reserves, (destinations), well plans are reaching reserves (access) – a way to reach the oil and gas.

## **Faster, better, cheaper**

Picture this: Six months before spudding a deepwater wildcat, the drilling team members are scratching their heads. Which rig will they contract? Will shallow water flow affect the casing scheme? Will they keep the fragile balance between pore pressure fracture gradient and mud weight? Which drilling fluid will they use in high-pressure zones? And will they deliver a well that flows, on time and within budget?

One way of managing budgets (as well as risk and uncertainty) is the Drilling Well Optimization Process (DWOP), also known as Drill the Well On Paper. We will look at this concept in greater detail in due course. However, for now it is important to define the technical limit for each activity, or minimum time required to complete each task in a perfect world. It serves as a theoretical value only and can never be achieved as an actual target. Next, a realistic target based on the best

DWOP is the process of analyzing each step of the well construction process to generate ideas for improving performance and reducing cost.

past performance is established, which becomes the performance benchmark for the well.

DWOP is the process of analyzing each step of the well construction process to generate ideas for improving performance and reducing cost.

### Blueprint

Getting to the blueprint stage requires various scenarios to be enacted (DWOP) and huge volumes of information to be analyzed and formatted. Well planning is a very broad concept that encompasses:

- the management of phased well construction service and supply processes to meet a desired timeline and objective;
- commercial aspects of contracts and pricing for well services and equipment;
- financial cover in terms of insurance and liabilities;
- legal conditions such as compliance with regulatory framework and outlining limits of responsibilities;
- design and operational aspects that cover detailed engineering drawings of well construction;
- health and safety considerations;

- environmental protection;

- political/cultural/linguistic aspects of operations.

There can be as many as a 100 different regulatory conditions and as many service and supply companies on a single well project. Subsequent issues will look in depth at regulatory issues such as permit to drill, supply and services procurement such as rig type, services contracts and well types but for now we shall look at the main features of well planning and accompanying risk and the engineering aspect of a vertical exploratory well.

### Essential Info

A well plan has essential information such as well number, location, block, partners, and the level of confidentiality will dictate if it is tight-hole (confidential). It will include the well objectives, Surface location, longitude, latitude, Eastings and Northings.

It will also contain well information such as water depths in the case of offshore wells, MD measured depth, TVD, azimuth, spud date and critical dates such as first oil or seasonal or environmental factors that may affect operations.

The Well Plan also includes such things as:

- Rig details, rig preparations, the transportation of the rig to site and setting it up;



- Well Control & Contingencies;
- Pressures (PPFG) and Temperature (Gradient);
- Directional and sidetracks at horizons;
- BHAs & Hydraulics;
- Casing Depths and Cementing details;
- Contact list of personnel;
- Completion info - how the final section of the well will be finished or completed.

### Targets

Targets usually refer to geological targets, which are the depths of formations that likely contain oil and gas. Depths are expressed as vertical and measured depths. True Vertical Depth for our purposes refers to a particular depth taken as a ninety degree straight line down to the depth of interest. The measured depth is the actual distance drilled. Other formations or markers along with their age and lithology ie sand/shale will be noted. The TVD is measured from the top of the target to the bottom height of the reservoir. When you read that reservoir had 78 feet of 'pay' or oilbearing sands that refers to the vertical height of oil and gas reservoir. 'First oil' refers to the time at which production of a certain reservoir occurs.

### In the dark

Reservoir information on exploratory drilling will be limited or even unavailable. However, there may be some

basic info on formation markers, porosity permeability, temperatures, expected hydrocarbon gas or oil. Reservoir pressure, formation markers, the TVD, the tops of formations, and a range of pressures will all need to be predicted. Only upon drilling will true values be confirmed. Most of the large integrated service companies offer down-hole formation pressure while drilling tools.

### Regulatory Compliance

All regulations including health and safety considerations and environmental protection will be cited and acted upon.

### Potential hazards

Hazards are identified as geological/formation related and environmental/operational. Exemplifying the former are shallow gas, shallow water flows, charged zones, depleted zones, overpressure, abnormal temperatures, presence of H<sub>2</sub>S, CO<sub>2</sub>, pressure faults. These will be covered in part by the Well Control Plan which will have considered all components of the wellhead and well control equipment.

This includes:

- All wellhead components
- BOP stack & valves
- Accumulator
- Choke and kill lines

Operational hazards range from well-bore positioning (such as avoiding collision with existing wells or pipelines), avoiding shipping channels, avoiding cetaceans or other protected marine life. Operational risks include maintaining casing integrity, avoiding casing wear (casing is metal tubing used to protect well-bores), maintaining well-bore stability and managing any pressure ramp near TD.

- Choke manifold
- Gas buster (or poor boy de-gasser)
- Drill string safety valves
- Standpipe manifold
- High pressure mud lines and system (including cementing system)
- Drill strings
- Drill stem testing surface and subsurface equipment
- Subsea well control equipment, if drilling from a floating vessel

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### **Formation Evaluation Plan.**

This plan will include provision for LWD or the Logging program. This will outline requirements for cuttings samples, mud logging and Formation logging. This

allows the oil company to characterize formations and understand actual drilling conditions which will vary from seismic. PWD tools exist also and can replace wireline or pipe-conveyed logging services and are made up as part of the BHA. This allows operators to measure formation pressure as they are encountered which improves well control, safety and drilling efficiency.

Potential hazards such as shallow gas flows or severe pressure changes can be noted earlier and preventative action taken which lowers risk and operational cost. Usually, these systems make use of binary coding using mud pulse telemetry where surface operator and subsurface tool communicate by means of pressure pulses that are sent through the column of drilling mud during drill-pipe connections.

### **Mud-logging System**

During drilling operations a multitude of measurements are taken and monitored. Temperature, pressure, depth, torque and loading are just a few. Several systems exist on rigs to fulfil this function with mud-logging being a primary one.

The use of mud-logging systems was first introduced in the industry in the 1960s. Since then, advances in instrumentation and in the number of measured parameters has resulted in much more sophisticated mud-logging systems.

Mud-logging systems encompass two different sorts of data. Firstly they collect and analyze formation samples (shale-shaker samples). Secondly, they measure and monitor mechanical parameters related to the drilling operation. Both provide invaluable data as to whether formations encountered bear oil and gas or how drilling is going.

The advent of deepwater drilling also contributed to the progress of mud-logging techniques. Deep and ultra-deep water environments require very accurately controlled drilling operations. Any failure or negligence may cause human injury and economic losses. To control processes accurately, enhanced mud-logging was required.

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### Examining Cuttings

Drilling chips or returns also known as 'cuttings' provide the operator with information as to whether hydrocarbons have been found, by carefully examining cuttings brought up by the circulating bit. The mud logger or geologist samples cuttings from the flow equipment uses a microscope or ultraviolet light to determine the presence of oil in the cuttings. Where gas reserves are concerned, he may use a gas-detection instrument.

During drilling, an operator will observe mud-logging parameters for any abnormalities. If an observed

parameter presents unusual behavior, the operator immediately communicates this to the driller who will carry out certain procedures to solve the problem. Actually, the system allows the programming of alarms that will sound in the mud-logging cabin, alerting the mud-logger that the value of the observed parameter is outside of the programmed range.

The number of observed parameters may vary according to a particular characteristic of the drilling operation. The most common measured parameters are: Well Depth (Depth), True Vertical Depth (TVD), Bit Depth, Rate of Penetration (ROP), Hook Height, Weight on Hook (WOH), Weight on Bit (WOB), Vertical Rig Displacement (Heave), Torque, Drill-string rotation per minute (RPM), Mud Pit Volume, Pump Pressure, Choke Line Pressure, Pump Strokes per minute (SPM), Mud Flow, Total Gas, Gas Concentration Distribution, H<sub>2</sub>S concentration, Mud Weight in/out, Drilling Fluid Resistivity, Drilling Fluid Temperature, Flow Line, LAG Time, and Stand Length.

It is noticed that only some of the listed parameters are really measured using sensor devices. Some of them are estimated from measured parameters. The WOB, for instance, is an estimated parameter. It is calculated using the WOH (a measured parameter) and the weight of drill-string elements.

Ultra high telemetry rates (12 bits per second) have been successfully used to optimize horizontal well placement as well as warn of wellbore stability issues before they become serious enough to jeopardize operations or impact drilling costs.

## Well Logging

Using a portable laboratory, truck-mounted for land rigs, well loggers lower devices called logging tools into the well on wire-line. The tools are lowered all the way to bottom and then reeled slowly back up. As the tools come back up the hole, they are able to measure the properties of the formations they pass.

Electric logs measure and record natural and induced electricity in formations. Some logs ping formations with sound and measure and record sound reactions. Radioactivity logs measure and record the effects of natural and induced radiation in the formations. These are only a few of many types of logs available. Since all the logging tools make a record, which resembles a graph or an electrocardiogram (ECG), the records, or logs can be studied and interpreted by an experienced geologist or engineer to indicate not only the existence of oil or gas, but also how much may be there. Computers have made the interpretation of logs much easier and logging tools using real-time transmission systems are now capable of imaging the wellbore as it is drilled.

Although, logging and measurement while drilling (LWD/MWD) tools have been available for many years, it is only recently that advances in data transmission and interpretation have progressed to generate accurate images of the wellbore. These images are based on real

time data and offer insight into what is really happening downhole.

Typically, a high quality image is drawn from detailed, three-dimensional resistivity data. This data is supplied by a resistivity tool similar to a logging formation micro-imager, which is run on wireline. The resistivity tool is capable of identifying wellbore features and characterizing faults, cementation changes and threaded or spiraling caused by bit whirl. Software transforms the resistivity data into images of 3-D wellbores that are viewable at all angles with simple mouse movements. The resistivity measurements are transformed into 56 azimuthal sectors around the circumference of the wellbore to provide extremely detailed images.

The combination of resistivity and density services based on real-time logging images and geo-steering techniques is likely to enable operators to reduce risk and overcome geological uncertainties commonly associated with complex wells.

Ultra high telemetry rates (12 bits per second) have been successfully used to optimize horizontal well placement as well as warn of wellbore stability issues before they become serious enough to jeopardize operations or impact drilling costs.

Wellbore stability problems are detected with ultrasonic calipers from density logging while drilling (LWD) tools.

The software also allows structural dip picking from images, which can be used in combination with the real-time data for structural interpretation. Bed dips and layer thickness are also characterized permitting the evaluation of structural cross-sections. The reduction in risk and geological uncertainty will make the advent of wellbore imaging hard to resist for production companies.

Hole enlargement or washouts can be identified while drilling or during subsequent trips. This is beneficial as it helps monitor wellbore stability and allows adjustments to be made to mud weights or effective circulating density as required. Wellbore stability problems are confirmed using vision technology incorporating Azimuthal Density/Neutron viewer software, which provides density image and caliper data while drilling. The software also generates 3-D images and caliper logs. Together, these offer easier methods of understanding well bore conditions during drilling operations. Additionally, the 3-D density images and ultrasonic caliper allow wellbore instability mechanisms to be better characterized, and when necessary, resolved. This is particularly important in completions where gravel packs or expandable screens are required. The ultrasonic and density caliper information gathered during drilling can indicate whether hole quality is good enough to permit specialized completions to proceed. While an up log obtained on a subsequent wiper trip allows visualization of the hole enlargement and stress failures after drilling.

Specialized software uses a recorded mode to gather real-time dip information, provided by the LWD resistivity imaging tools. This information is harnessed to view geological structures and reduce the uncertainties in pre-existent geological models. Analysis of surface seismic can also help indicate the possibility of erosion surfaces,

which can jeopardize well navigation. Specialized data transmission from the rig site allows continuous observation of the wellbore to anticipate changes in the bedding plane and structure behavior of the reservoir.

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### **Pressure While Drilling**

These types of tools are used to make accurate downhole measurements of:

- Equivalent circulating density (ECD);
- Kick detection, including shallow water flows;
- Swab/surge pressure monitoring while tripping and reaming;
- Hole cleaning;
- Hydrostatic pressure and effective mud weight;
- Accurate leak-off test (LOT) and formation integrity test (FIT) data. 

# EP in Rub



# Al Khali

It is the marine organisms of eastern Saudi Arabia's ancient sea that, settling to the bottom over millions of years, eventually became trapped in subterranean deposits of oil and natural gas. Gas deposits, specifically gas and condensates existing independently of oil reservoirs (non-associated), are what the South Rub' Al-Khali Co. Ltd. (SRAK) has been exploring for in The Empty Quarter since 2004.

Reproduced from Saudi Aramco Dimensions Magazine

## The Rub

This is an archetypal sand desert that seems haunted by its own vastness, its own austere beauty. It is one of the largest continuous sand deserts, encompassing 582,750 square kilometers (225,000 square miles) of the Arabian Peninsula. SRAK, an incorporated joint venture company operating on behalf of its three shareholders (Shell with 40 percent and Total and Saudi Aramco each holding 30 percent), inaugurated its first well in July 2006. The drilling rig is a fragile appearing metal latticework frame 65 meters (213 feet) tall, which seems tiny and insubstantial amid the hugeness of the desert.

According to the terms of the Upstream Project Agreement with the Saudi Arabian government, signed during ceremonies in Riyadh on November 15th 2003, the newly formed company had only five years to explore the geology of an area equivalent in size to the United Kingdom. One thing was clear. To do so in any comprehensive manner would be an impossible feat. In addition, the contract stipulated that seven wells were to be drilled during that time.

In a perfect world, drilling engineers know ahead of time how deep they need to drill and what types of rocks they will encounter at various depths. The problem for SRAK drilling engineers was the lack of geological data on their contract area in the southern Rub' al-Khali Basin.

SRAK drilling manager Koen Bracquene is a man long accustomed to the realities of the imperfect world of exploration and drilling. "Based on very preliminary geological data, you make your conceptual design calculations for different situations, and worst case scenarios in particular," he said. "From there, you start looking for a drilling unit and your long delivery equipment — the pipes, the valves and the flanges to put on the wellhead. Because of the specific requirements and the prevailing market conditions, that process typically takes about a year."

A year, plus a minimum of two years before SRAK generated data would reveal the most promising site for a well. Before SRAK could even hope to get its first well started, three of the five years were already gone. Under that timeline the math wasn't adding up.

Bracquene and his team got to work making the most accurate drilling plan they could, along with contingencies to cover as many geological uncertainties as possible. The last thing they wanted was to start drilling a well only to find that they didn't have bits of the correct hardness or pipe of the correct specifications to complete the well to the required depth. That could delay progress for a year they could ill afford to lose.

“It is very rare in the world these days that you get an opportunity to explore a basin pretty well from scratch and to turn a blank piece of paper into a portfolio of prospects”. (Allman-Ward)

Every day became a race for information. Over the years, 20 test wells had been drilled within the SRAK contract area. Imagine 20 straws sunk randomly into the ground across the whole of Scotland, and you begin to understand not only the scale but also the limitations of any information the geologists might obtain. Furthermore, only five of the wells were drilled to a depth at which gas might reside. Analysis of core and cutting samples from those wells would provide the first few pieces of the puzzle, albeit not the prized edge pieces. A little more information was gleaned from a Saudi Aramco airborne magnetic survey done in the early 2000s that overlapped into the northern edge of SRAK acreage. The Saudi Geological Survey also had some magnetic data that SRAK acquired. After integrating all of the well and seismic data at their disposal, a hazy picture began to form and obvious questions arose. How do you acquire enough geological data to exactly pinpoint the seven best well sites in a 210,000-square-kilometer area? How do you engineer and drill seven wells in five years when you don't have the information you need and when materials for each one could take a year to manufacture and get on site? How do you accomplish all of this in one of the most remote deserts on the planet and one of the last places on earth to be explored, where the climate is severe and there are no roads?

Depending on your perspective, this could either be an absolutely appalling prospect or a dream come true. For SRAK CEO Patrick Allman-Ward, it was both.

“It is very rare in the world these days that you get an opportunity to explore a basin pretty well from scratch and to turn a blank piece of paper into a portfolio of prospects,” he said. “Most geologists spend their lives re-mapping prospects that other people have already mapped. In this project we are putting new prospects on the map that have never been seen before. That, of course, is very exciting.”

He also knew that time and technology had fortuitously conjoined at this moment to give this venture its best chance for success. There had been tentative attempts to unlock the secrets of the Rub' al-Khali before, of course. With a few exceptions in the north, most had been defeated by the combination of extreme conditions and distances.

To do it right, Allman-Ward knew he would have to take advantage of every new technological advancement. He would have to assemble teams of people who knew how to turn challenges into opportunities. To prevent mutiny en masse, he would need to make the desert camps as comfortable as possible. Environmental impact





studies would need to be undertaken. Health, safety and environment (HSE) standards would have to be implemented and strictly adhered to. And exploration efforts would have to be coordinated with government agencies interested in the preservation of any archaeological sites that might be discovered. Allman-Ward and SRAK had one chance to bend to their will the collective forces that would result in success. There would be no cutting corners. They would do it right.

SRAK CEO Patrick Allman-Ward reveals why he thinks this area has such large hydrocarbon reservoirs compared to other places around the world.

“It always puzzled me a little bit as to why Saudi Arabia was so uniquely blessed with such an abundance of hydrocarbons. I think for most geologists and seismic interpreters who are familiar with mature areas of exploration, if you find a new prospect it will typically be a prospect of a few square kilometers. One of the exciting things about the acreage we are exploring is that we are mapping for the first time some very large structures indeed, with an aerial extent of hundreds of square

kilometers in some cases. I think one of the keys to the large prospects found here is that the Arabian platform, which is the name for the plate on which Saudi Arabia sits, has actually been very stable over geological time.

“Part of the regional geological work we have done has established that the Arabian plate came together from a series of smaller plates between the Pre-Cambrian and Cambrian period. So we’re talking 600–800 million years ago when the Saudi Arabian plate was welded together in its present form. Since then the plate has gone up and down relative to sea level, and has experienced a series of flooding and erosion events. When sea flooded over the top of the plate, it created accommodation space for sediments to be deposited either in the form of clastic sediments or carbonate sediments. These provided the source rocks, the reservoirs and the seals. And when the sea retreated, the sediments were exposed and eroded. But in fact, the overall internal structural deformation in the Arabian plate has been relatively minor. It has remained largely undisturbed. Yet all around the edges of the Arabian plate, a whole series of plate tectonic mountain-building events has occurred.

“We have a large number of structures we are mapping and discovering in this area,” Allman-Ward explained. “But then the question becomes: Which are the good ones and which are the bad ones? You have to prioritize the prospects for drilling, and that’s the process of de-risking.”

The consequence was some subtle re-activation of structures within the Arabian plate as a result of these far-field stresses.

“Subtle changes mean the structures are very large because they haven’t been fragmented and broken up into tiny pieces. The Saudi Arabian plate seems to be full of these very large structures, because it has not been subjected to intense tectonic events. It has been subjected to relatively mild far-field events that have subtly remobilized faults and fractures and created the structures that we currently see. And then, of course, you have two world-class source rocks; some people say more than two, which also help to fill these very nice structures with hydrocarbons.”

### Data exploration

Meanwhile, SRAK geologists were trying to decide how to quickly acquire the most useful seismic data in their massive contract area.

“Our strategy was to try and find a means by which we could implement a focused exploration program, centered during the first two-and-a-half years on finding the hot spots in outer contract area,” said Allman-Ward. “Ultimately, that meant applying every geological trick that we had in order to zoom in and focus on the pieces of acreage that we needed to expend time and effort in.” To accomplish this they used a methodology called play-based exploration. In play-based exploration, you step back and look at the terrain in a holistic way instead of just trying to map prospects or structures. You take into account the natural history of the terrain and how it evolved through time in terms of its structural evolution and the deposition of sediments and source rocks. Then you evaluate how those source rocks have matured through time and at what point hydrocarbons may have



been expelled out of those source rocks and to where they might have migrated.

Knowing that they had one chance to coax a grudging desert into revealing its mysteries, a serious multi-pronged exploration program ensued. SRAK used unconventional technologies such as low-frequency (acoustic) seismic surveying and magneto tellurics, as well as conventionally acquired seismic data from vibroseis trucks and satellite imagery. And in its effort to locate the contract area’s

But those plans could get reshuffled at a moment's notice, depending on what additional data comes to light. The men of SRAK understand the *sarab*, the mirage, because they live in a realm where images are constantly shimmering in the heat of scrutiny and wavering in and out of focus. But that's part of the challenge.

elusive hydrocarbon deposits, SRAK would eventually conduct what would become the largest high-resolution airborne gravity survey in the world.

### **An educated guess**

After more than two years of exploring, surveying and mapping their contract area, SRAK narrowed in on where to drill their first well. Frustratingly, even with all the data at their disposal, the site selection was little more than an educated best guess. Why?

"In some areas of the world (the Gulf of Mexico, Nigeria, the Far East, etc.), you get a strong indication of whether you have hydrocarbons from the seismic data," Allman-Ward stressed. "We don't have that luxury. In all of our areas, the rocks are old as opposed to being very young. Old rocks don't respond in the same way to the presence of hydrocarbons and therefore don't show up on the seismic data directly."

When dealing with an entity such as the Rub' al-Khali, the people of SRAK will tell you that they don't expect things to be easy. Instead, they shore up their positive attitudes and make contingency plans. In this case, the first well would be considered a true blind test. From there they would do something geologists call *de-risking*.

"We have a large number of structures we are mapping and discovering in this area," Allman-Ward explained. "But then the question becomes: Which are the good ones and which are the bad ones? You have to prioritize the prospects for drilling, and that's the process of *de-risking*."

For a while, though, it looked like SRAK wasn't going to meet its tight timeframe. All the equipment that

Bracquene had ordered over a year ago was now being delivered at the SRAK storage yard in al-Khobar. There was just one small problem: As the five-year clock continued to count down, Saudi Aramco had recently embarked on a major expansion of its exploration program, and the suitable drilling rigs, well construction and evaluation services throughout the Kingdom were being used.

Not ones to be discouraged easily, representatives from SRAK had launched an area-wide search and had found a suitable rig in Dubai. All they had to do now was have it trucked nearly 2,000 kilometers through the desert to the well site. Also, for the over-desert trek they would need specially rated trucks. That was fine. They were even willing to build basic roads where none existed.

SRAK officials said that results from *Isharat-1* have been very encouraging and have shown that the venture's geological model for the region is gratifyingly accurate. SRAK hopes to spud another exploration well — *Al-Mirtan* — in early March 2007. But, gas or no gas, SRAK is gathering critical information with which to recalibrate their ever-changing model of the Southern Rub' al-Khali Basin. They've already moved the location of their second well when new information was analyzed. That decision resulted in an additional 200 kilometers of road that needed to be built and completed in three months. Work at that well site is now under way and plans are being updated for the third well and beyond.

But those plans could get reshuffled at a moment's notice, depending on what additional data comes to light. The men of SRAK understand the *sarab*, the mirage, because they live in a realm where images are constantly shimmering in the heat of scrutiny and wavering in and out of focus. But that's part of the challenge. And they wouldn't be in this business if they didn't welcome a challenge. 🕯

# Black blessing

By Wajid Rasheed

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 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 learnt.

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 specialized 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'. But this 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 – Norway and UK in the 1986 crash.

## **Before Oil**

When considering the North Sea – Stavanger, Norway, Aberdeen, UK and the Arabian Peninsula – Saudi Arabia and Dubai, UAE, it is revealing to see how these countries existed before oil.

# Within a century oil and gas have become the world's preferred energy source. Consequently, certain countries with the black blessing have benefited. This article looks at ways of making the blessing last.

Dubai's Palm-Jumeirah Island was created by using reclaimed sand from the sea. The landmark development in the shape of a palm tree typifies how oil wealth has been used to attract tourism.

Photo: Juergen Stumpe

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

Undoubtedly, this shows that the black blessing has improved lives within the space of a single generation and has led to the creation of new industries.

## Pilgrims

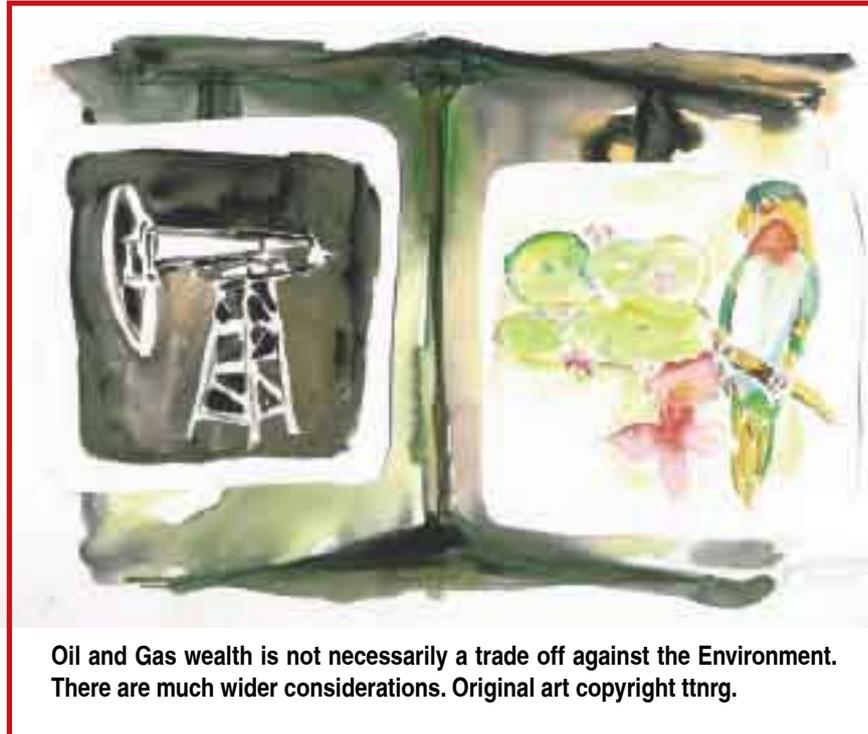
In the Saudi Arabian peninsula, oil was discovered in the 1930's. At that time, exploration contracts for oil were scorned; in scorching desert temperatures, exploration was for a more valued resource; water.

Saudi Arabia had already been guaranteed an annual source of revenue due to the Hajj – the pilgrimage Muslims made 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 reflect this reaching 50%. Other stipulations such as the improvement of transportation and telecommunication links followed. By the 1970's the Saudis had started to buy-back the privatized oil company leading to the full ownership of Aramco and the country's estimated 262 billion barrels of oil.

In reality, National Oil policy has come full circle (see graphic overleaf). It has evolved from seeking maximum royalties to stipulating local capacity to full renationalization and now to partial privatization for Gas developments (see ttnrg 2 Bids and blocks Section 1). To illustrate Saudi Aramco's local content, as of 2003 it had 53,954 employees, of which 86% or 46,365 were Saudi nationals. It has also signed gas exploration contracts with foreign oil companies.



## Gold and Pearls

In the UAE – a union of seven Emirates – the situation was different. Dubai had long been a regional trading hub. It'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 1930's.

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 UAE and Dubai that oil exploration licenses were being sold in Saudi; negotiations followed.

With the fullness of time, this led to the discovery of reserves of approximately 100 million barrels of oil. 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

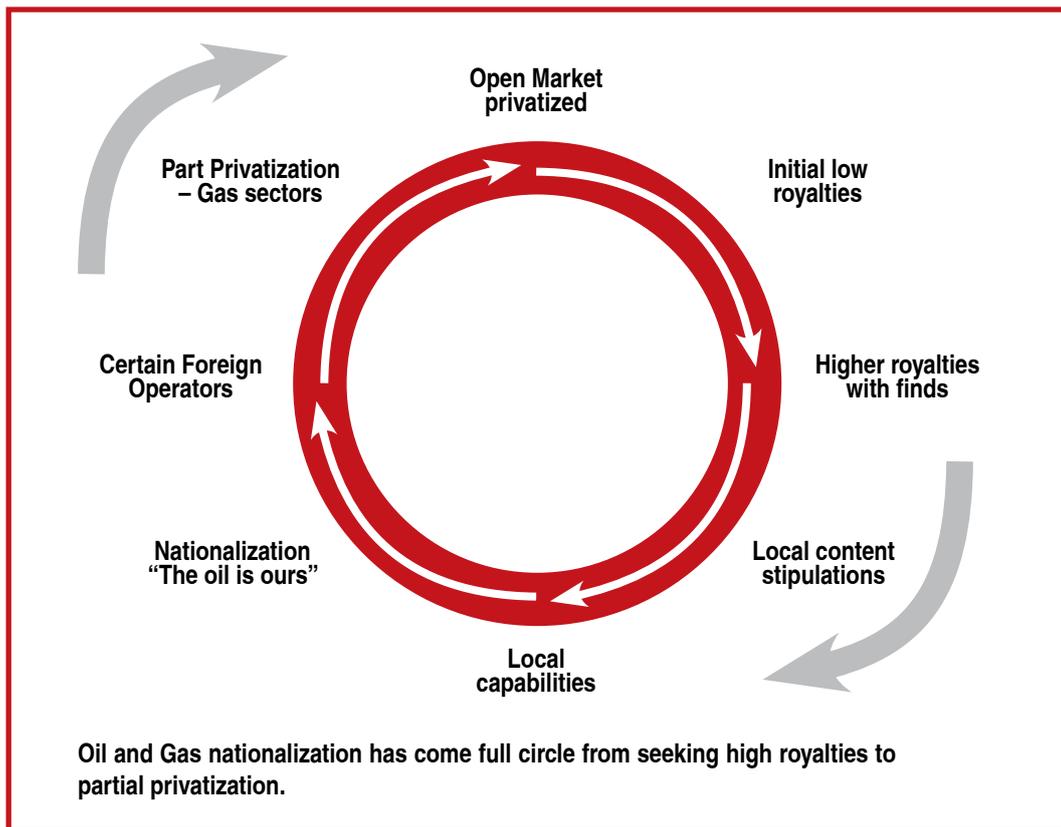
1960s when gas was first discovered (oil came afterwards) in the Groenigen field in the Dutch Sector of the North Sea, Norway had high employment, a current account surplus and low inflation. From a socio-economic perspective, there was no pressing need to explore for, and develop oil and gas.

But with the 1973 Oil crisis and accompanying embargo geologists started scrambling for North Sea seismic. This instability in global geo-politics set the scene for the upper hand in negotiations with the international oil companies. When the Norwegians and Scots asked for rewards beyond taxes and royalties, the oilmen obliged.

## 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 in the ground and chances are that oil will be struck. Therefore, from the very start these very different environments formed very different mindsets.

As noted earlier, oil is much easier to access in the Arabian Peninsula than in the North Sea. This led to a laissez-faire approach in the Arabian Peninsula. It seemed that all that



was necessary was to sink a simple shallow vertical hole and a huge field would be found.

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 and the gradual introduction of terms such as the famous ‘50% local content’ stipulation in exploration contracts.

### 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.

For example, North Sea offshore operations routinely cost in excess of \$200,000 per day including rig rental and crew costs. By contrast, onshore operations in the Arabian Peninsula do not often exceed \$100,000. Additionally, the profile of Arabian reservoirs ie 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.

However, by the 1980’s there was greater emphasis 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 60’s, 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?

Building local capabilities was always a ‘must-have’ for the North Sea. This created the backbone current oil and gas technology exports. Technologies were invented,

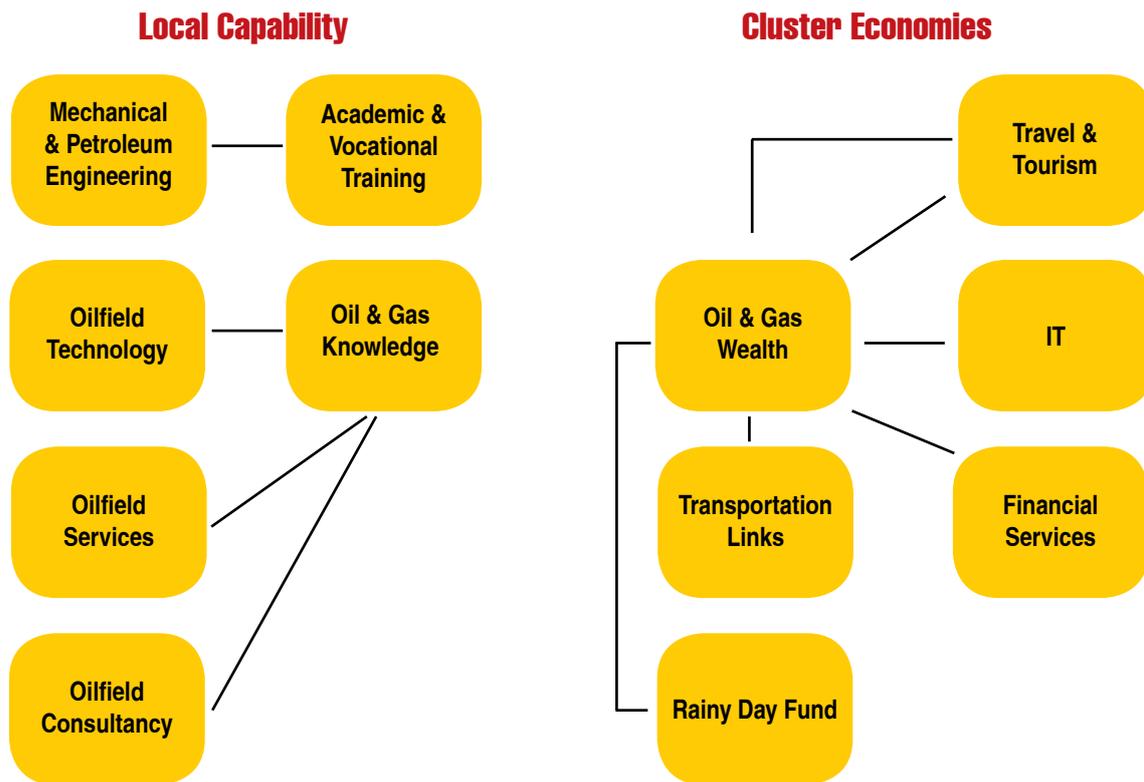


Diagram shows the relationship of Oil and Gas in economic sustainability.

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 seventies this led to the preferential use of local goods and services at times reaching 90% as required by law. In the early 70's, 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 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 programs 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 million barrels per day. The UK's oil production has fallen by 30% over the same period to current levels of 2 million barrels per day. Yet, through demand for UK oilfield goods and services, the oil sector continues to generate substantial economic activity.

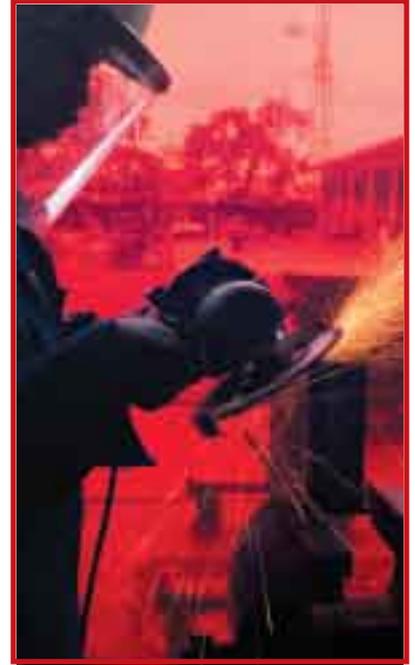
Smaller independents have entered the UK sector but the oil and gas industry has developed far more due to the formation of mechanical and petroleum engineering, academic and vocational training and associated consultancy services.

### 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 received training in the IOC training programs and overseas postings.

The situation was slightly different for the UK as British Petroleum (BP) had already had international oil and gas exposure. In fact, this helped it discover and develop Forties the largest North Sea UK field.

## The oil industry can be used to build local engineering capacity.



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 Research and Development; several test wells 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 appease cost considerations; 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. However, for the most part 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. National oil companies 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, real time operations management.

### Cluster Economies

It is recognized that the Arabian Peninsula's economies have been highly dependent on oil; it accounted for more than 75 per cent 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.

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 global leading media companies. Dubai's financial markets have also grown. According to Chatham House Dubai market capitalization rose from US \$14.3 billion in 2003 to US \$28.6 billion in 2004.

Undoubtedly, this shows that the black blessing has improved lives within the space of a single generation and has led to the creation of new industries. As we have seen there are many ways to make the blessing last.

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 has first sought to consolidate the economy's major components of trade, transport, tourism and real estate sectors. Then to promote aspects of a 'new economy': IT and multi-media activities and e-commerce and capital intensive, high-tech manufacturing and services.

### **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 the passage of time the local knowledge base and competence was created.

However, 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 has led to the creation of new industries. As we have seen there are many ways to make the blessing last.

*Acknowledgements: Chatham House, The Royal Institute of International Affairs. NPD Norwegian Petroleum Directorate, Saudi Aramco and Dubai Media City, BP statistical review.* ♠



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# The chance of a lifetime

## Expatriate recruitment administration

Reproduced from Saudi Aramco Dimensions Magazine

**Q: Saudi Arabia Oil and Gas** – What is the role of the Expatriate Employment Division?

**A: Gerard W. Fitzgerald** – Although Saudi Aramco's workforce is primarily Saudi Arabian, we, like any major international operation, require a large number of skilled people who come here from around the world. So it is the EED's job to staff positions for Saudi Aramco from locations outside Saudi Arabia to supplement the hiring of Saudi nationals.

**Q: Saudi Arabia Oil and Gas** – Why are so many new hires needed by Saudi Aramco?

**A: Gerard W. Fitzgerald** – Right now we have an enormous capital program under way to extend our upstream capabilities. Like most oil companies today, we are constantly searching for well-qualified and motivated people to add to the team.

**Q: Saudi Arabia Oil and Gas** – What types of positions need to be filled?

**A: Gerard W. Fitzgerald** – Saudi Aramco are hiring across a wide spectrum of upstream specialties including rig

supervisors, drilling and petroleum engineers, consultants, and of course, geoscientists. There are vacancies for rig safety personnel and rig electrical technicians. We are also actively recruiting in the downstream area in addition to other support functions to include loss prevention, finance and medical personnel.

**Q: Saudi Arabia Oil and Gas** – In which countries are you recruiting?

**A: Gerard W. Fitzgerald** – The oil business is truly global, and the same goes for our recruiting efforts. We have a long history of recruiting from North America, Europe, the Arabian Gulf States and Indian subcontinent. More recently, we have been successful in finding people from South America and other Asian countries — most notably Malaysia and Indonesia.

We have also hired from Africa. Last year, we hired nationals from more than 30 countries, so you can see that our business knows no boundaries.

**Q: Saudi Arabia Oil and Gas** – What factors do you consider in deciding which countries to recruit from?

**There is a tremendous worldwide need for increased energy production. Saudi Aramco has initiated many exploration and drilling projects as well as increasing upstream activities. This drive has created many opportunities for skilled workers.**

**In this interview, Gerard W. Fitzgerald, administrator of Saudi Aramco's Expatriate Employment Division (EED), answers questions about expatriates working for Saudi Aramco.**

## Director lauds Saudi Aramco experience

**A: Gerard W. Fitzgerald** – Clearly an established oil and gas industry is an obvious factor. Then we look at the quality of potential new hires in terms of education, training and experience. It is important the people we hire are ready to hit the ground running and have the necessary skills and experience to make an immediate impact. We are a global leader in the industry and we expect our new employees to excel in their fields.

**Q: Saudi Arabia Oil and Gas** – What are the dates and locations of recruiting events?

**A: Gerard W. Fitzgerald** – We attend many professional conferences and recruiting events on a regular basis. For example, we often have a presence at major SPE, IADC, SEG and EAGE events, in addition to organizing road shows where we target a specific country and go with our hiring organizations to market our opportunities.

**Q: Saudi Arabia Oil and Gas** – Why should skilled workers want to work for Saudi Aramco?

**A: Gerard W. Fitzgerald** – There are many reasons, and we would need all day to talk about the countless benefits of being here. However, I would summarize the reasons as follows:

- Great compensation and benefits package, which allows you to save a lot of money for your future.

- Top-class lifestyle, not to mention being in an environment where the company takes so many hassles out of normal day-to-day living.

- The chance to work on truly world-class projects and be part of the finest oil company in the world.

- Excellent education opportunities for children — whether through the company's first-rate private schools, international schools in Saudi Arabia or in world-class overseas boarding schools for older children.

- Travel opportunities — for Aramco employees, travel to exciting locations is a way of life here.

**Q: Saudi Arabia Oil and Gas** – Interesting — could you elaborate more?

**A: Gerard W. Fitzgerald** – Sure. Take the financial aspect to begin with. Not only do employees get an excellent salary but a wide range of benefits to go with it. Salary increases are good, and the compound effect over time means that financially people become very well off. You meet people after they have been here a few years, and they say, "When I was first hired, I never realized just how good the package would turn out to be."

“Saudi Aramco does a really great job of ensuring the family is taken care of. We are not just hiring the employee. We are hiring his family too — important not to forget this.”

You see, people who have never been on an expatriate package like this cannot fully appreciate the huge savings potential. It is not just that you are paid well; it is also the fact that your expenditures can be so much less than at home. Of course, it all depends on the individual's spending pattern how much you end up saving, but it is worth noting that the modest “housing rent” you pay means goodbye to home repair and maintenance costs. You don't have any local authority housing tax — such as in the UK, where you pay “council tax”; you have no electricity or gas bills; local phone calls are free and you can use the many internet options for overseas calls, which means communication costs are low; and you don't need to bear the expense of two new cars for your transportation needs. Speaking of which, petrol prices are very low, especially compared to costs in Europe, and things like car insurance are a fraction of what you would pay in Europe or the States. These are just a few examples. I could elaborate further but I would need all day to detail them!

**Q: Saudi Arabia Oil and Gas** – You mention lifestyle and the fact Saudi Aramco takes the hassle out of day-to-day living. What do you mean by that?

**A: Gerard W. Fitzgerald** – Well, let me explain about the housing theme I mentioned previously. Let's say your company-provided dishwasher breaks down or the trees in your garden need trimming. At Saudi Aramco, you call the maintenance

and gardening people and, before you know it, problem solved. It wouldn't happen as easily back home, not to mention the associated cost. It is your child's birthday and you want to have a party — you call Recreation, and a truck pulls up with garden tables and chairs. Life after work is seductively easy, to be honest with you. Let me give you a typical example: Let's say you coach your daughter's soccer team (or it could be baseball, softball, cricket or whatever). Once you get home from work, it's just five minutes to the field, and you can spend an hour coaching the team, usually in fine weather. You then go and play a game of tennis with your friends at the (free-of-charge) courts down the street, which means you are back home in time for supper and still able to enjoy the rest of your evening!

**Q: Saudi Arabia Oil and Gas** – What about the issue of education for children?

**A: Gerard W. Fitzgerald** – Saudi Aramco does a really great job of ensuring the family is taken care of. We are not just hiring the employee. We are hiring his family too — important not to forget this. So what does the Company do regarding education? Saudi Aramco has set up a superb schooling system in each family community. Class sizes are small relative to back home. Facilities are outstanding. But, the real strength of Saudi Aramco Schools lies with its eager and motivated children, committed and dedicated staff and highly supportive parents. Together these factors add up to a wonderful learning environment. The same is true of the many international schools in the area, such as the Dhahran British Grammar School, which many of our European children attend. There are also Asian schools nearby such as the Indian and Pakistani schools. Extra curricular activities provide the opportunity to take some really exciting trips. Recently, children from Saudi Aramco Schools enjoyed trips to Africa, Switzerland, Turkey and Jordan. Earlier this year, the British Grammar School had a group of children who headed to Borneo in Malaysia for a 17-day adventure. They can't experience that at home!





“We offer the chance for the Drilling supervisor and his family to enjoy this great expatriate lifestyle experience”.

**Q: Saudi Arabia Oil and Gas** – You mention boarding school — does Saudi Aramco provide support in this area?

**A: Gerard W. Fitzgerald** – Absolutely. This is a real plus for the employee as the company pays room, board and tuition fees up to an established maximum, as well as providing air tickets three times a year for students to return home during school breaks. In addition, employees don't have to send their children to schools in their home country. I know a number of employees who send their children to superb international schools in places like Switzerland and elsewhere.

**Q: Saudi Arabia Oil and Gas** – What about the working environment and opportunities?

**A: Gerard W. Fitzgerald** – I mentioned at the start about our capital expansion program. This is the largest

ever in the industry. Our active rig count was 83 as recently as 2005, rising to 120 by the end of 2006. On the exploration side, plans are in place to drill 120 exploration wells. But it is not just upstream, there are world-class projects going on across company. There is ambitious gas exploration under way with joint venture companies. The company is also working on plans to build new export refineries and integrate existing refineries with new petrochemical projects. These are just a few examples. Industry professionals can find truly staggering opportunities here.

**Q: Saudi Arabia Oil and Gas** – Some people in the industry are used to working a period in the field and then flying back to their home country on days off. I understand your schedule for Drilling supervisors means that they can bring their families to Saudi Arabia.

“There are many opportunities here for expatriates to learn more, to grow, to enjoy work and life in perfect balance. People often come here with a short-term perspective and say, ‘I’ll try it for a year or so’”.

**A: Gerard W. Fitzgerald** – Correct. We offer the chance for the Drilling supervisor and his family to enjoy this great expatriate lifestyle experience. He works on the rig for two weeks and then gets to spend a week with his family at home. It is usually a short distance back to home so no long flights or airport queues. Everything I mentioned above is available for the employee in terms of the easy home life, high savings potential, great educational opportunities for his children, holiday travel opportunities and more. In terms of earnings, our package is superior to the average “day rate” that Drilling supervisors earn when you add up all the extras. Although the day rate might look good, when you compare the costs associated with maintaining a household in the home country compared to Saudi Arabia, the income tax issues that can arise, and then add on the extra financial benefits of the Saudi Aramco package over and above monthly salary, whether it be the company-matched savings plan, the retirement plan or an annual lump sum in lieu, the Saudi Aramco package wins hands-down.

**Q: Saudi Arabia Oil and Gas** – What are the roadblocks to expatriate recruitment?

**A: Gerard W. Fitzgerald** – There are a few — first there is intense global competition for oil and gas professionals. Thankfully, we have wonderful opportunities to offer people, so we are an attractive option for people to consider. Second, the demographics of the industry means there are fewer people around nowadays compared to 10–15 years ago. In the employment business we call it the “big crew change” as we replace retiring workers with younger professionals. Finally, there is the problem of negative media bias about this region in general. This

is a real shame as the media overplays any negative aspect and ignores all the positive ones. We offer both financial and physical security.

**Q: Saudi Arabia Oil and Gas** –Have expatriates been successful working for Saudi Aramco?

**A: Gerard W. Fitzgerald** – Absolutely. There are many opportunities here for expatriates to learn more, to grow, to enjoy work and life in perfect balance. People often come here with a short-term perspective and say, “I’ll try it for a year or so”. Well, you might be surprised to know the average length of stay among our drilling and workover expatriates approaches 10 years. Indeed, some employees stay 20 years or more. Also, when you consider the high number of employees who have left for one reason or another and then come back (we call them retreads), it tells you the company is doing something right for employees.

**Q: Saudi Arabia Oil and Gas** –Do you have any advice for job seekers who want to work for Saudi Aramco?

**A: Gerard W. Fitzgerald** – We tell people we are offering “the opportunity of a lifetime.” We mean it. My advice is: Come on over. You’ll be glad you did.

**Q: Saudi Arabia Oil and Gas** –How can anyone interested in careers with Saudi Aramco find out more information and apply for jobs?

**A: Gerard W. Fitzgerald** – The easiest way to learn more and to apply is via our website at [www.jobsataramco.com](http://www.jobsataramco.com). You can find out more about the lifestyle and benefits there and also cut and paste a resume to apply online. 📄

Norway Oil and Gas, tt\_nrg, Saudi Arabia Oil and Gas

2007 – Issue 4

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# Brazil oil & gas

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Jose Formigli  
Part 1



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Rosana Lomba  
Fluids



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