THE INTERNATIONAL MAGAZINE OF THE BP GROUP **ISSUE 1 2013**

BP MAGAZINE

SHIFT WORK

BP Magazine talks to geologists to learn how understanding the movement of the Earth's tectonic plates can help locate new sources of oil and gas.

Welcome. While technology has revolutionised the way in which we find and produce oil and gas, some things in the industry don't change; such as geologists getting out of the office to study rock formations in the search for clues as to how hydrocarbons might develop in similar formations buried miles below the Earth's surface. Over the past 40 years, though, this 'field work' has been enhanced by improved knowledge of how the Earth's tectonic plates move. In this edition (page 8), we talk to some of BP's geologists to find out more and meet one of the men credited with making the 'final' breakthrough on tectonic plate movement back in the 1960s. We also meet some of the team involved in delivering safe, reliable operations every day within BP's upstream business (page 16) and find out how BP has gone from zero wind capacity to being the fifth-largest wind power producer in the US in just six years (page 24).

Lisa Davison> Editor

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managing editor
David Vigar
david.vigar@bp.com

editor
Lisa Davison
lisa.davison@uk.bp.com

distribution
Carolyn Copland
+44 (0) 20 7496 4340

design
Phil Steed – Steed Design
phil@steeddesign.com
www.steeddesign.com

print management
Williams Lea

image contributors
BP Imageshop
Getty Images

Cover image: Jayne Fitzgerald from BP Libya's exploration team analyses a Triassic-aged source rock along a roadside outcrop in Italy. Behind her is Richard Woodfine. **Photograph by Richard Davies**

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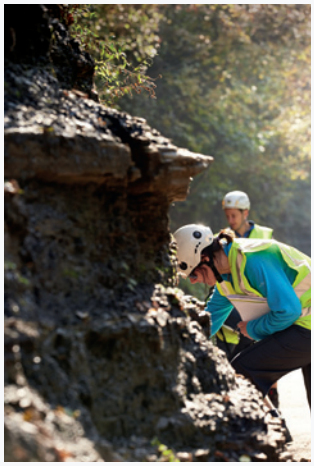

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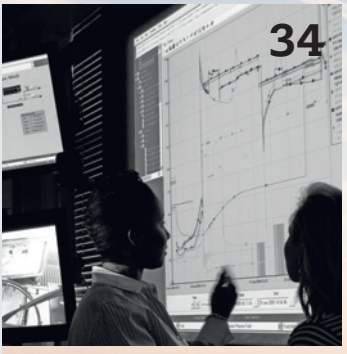


24 Aerial view

BP Magazine finds out how the company became the fifth-largest wind power producer in the US.

TNK-BP: DEFINITIVE SALE AGREEMENTS SIGNED

BP, Rosneft and Rosneftegaz – the state-owned parent company of Rosneft – have signed definitive and binding sale and purchase agreements for the sale of BP's 50% interest in TNK-BP to Rosneft and BP's investment in Rosneft. BP and Rosneft agreed heads of terms for this transaction on 22 October.

The agreements were signed after the Russian Government approved BP's purchase from Rosneftegaz of a 5.66% stake in Rosneft for $4.8 billion, as an integral part of the transaction. On completion, the net result of the overall transaction will be that BP will receive $12.3 billion in cash and acquire an 18.5% stake in Rosneft for its stake in TNK-BP. Combined with BP's current 1.25% shareholding, this will result in BP owning 19.75% of Rosneft.

Completion of the transaction is subject to certain customary closing conditions; the two companies anticipate completion in the first half of 2013. BP and Rosneft have begun discussions on how BP can best support Rosneft's strategic priorities, both as an investor and a strategic partner.

On 22 October, BP's group chief executive, Bob Dudley, said: "This investment builds on BP's track record of value creation in Russia. It is consistent with our strategy of deepening our positions in the world's most prolific oil and gas regions. BP intends to be a long-term investor in Rosneft – an investment which I believe will deliver value for our shareholders over the next decade and beyond."

BP's chairman, Carl-Henric Svanberg, said: "Russia is vital to world energy security and will be increasingly significant in years to come. Russia has also been an important country for us over the past 20 years. Our involvement has moved with the times. TNK-BP has been a good investment and we are now laying a new foundation for our work in Russia.

"Rosneft is set to be a major player in the global oil industry. This material holding in Rosneft will, we believe, give BP solid returns. We consider that this is a deal that will deliver both cash and long-term value for BP and its shareholders. It provides us with a sustainable stake in Russia's energy future and is consistent with our group strategy.

"Over the coming months, we will work hard to complete the transaction and we look forward to the next step of deepening our already strong relationship with Russia."

Meanwhile, BP and Alfa-Access-Renova (AAR), joint shareholders in TNK-BP, have announced that they have reached a comprehensive agreement to settle all outstanding disputes between them, including the current arbitrations brought by each against the other.

The agreement includes an immediate waiver of the new opportunities provision in the TNK-BP shareholder agreement, allowing each party to explore new opportunities and partnerships in Russia and the Ukraine, effective immediately.

"Russia is vital to world energy security and will be increasingly significant in years to come."

Carl-Henric Svanberg

127%

Rosneft's proved oil reserve replacement ratio in 2011

2.5 million

The number of barrels of oil per day produced by Rosneft in 2011, a rise of 53% since 2006

9.96 billion

Rosneft's proved developed reserves in barrels of oil equivalent as at the end of 2011

$10.8 billion

Rosneft's total net income for 2011. Its dividend for the same year was 25% of IFRS net income

NEWS IN BRIEF

Global

New upstream head

BP has appointed Lamar McKay as chief executive of its upstream business. He will take up the position with effect from 1 January 2013.

US

Refinery sale

BP has agreed to sell its Texas City refinery and a portion of its retail and logistics network in the southeast US to Marathon Petroleum Corporation for $2.5 billion.

UK

North Sea sale

BP is to sell its interests in a number of central North Sea oil and gas fields to TAQA for $1.058 billion. The assets included in the sale are BP's interests in the BP-operated Maclure, Harding and Devenick fields and non-operated interests in the Brae complex of fields and the Braemar field.

Canada

Block success

BP has won access to four deepwater exploration blocks offshore Nova Scotia, Canada. The blocks together cover an area of almost 14,000 square kilometres (5,400 square miles) and in water depths ranging from 100 to more than 3,000 metres (330-9,840 feet).

Trinidad and Tobago

Gas discovery

BP Trinidad and Tobago has discovered an estimated 1 trillion cubic feet (tcf) of gas offshore Trinidad, doubling the estimated gas in place of the Savonette gas field to 2tcf.

AGREEMENT OVER DEEPWATER HORIZON CHARGES

BP has reached agreement with the US Government, subject to court approval, to resolve all federal criminal charges and all claims by the Securities and Exchange Commission (SEC) against the company stemming from the Deepwater Horizon accident, oil spill, and response.

In eliminating the possibility of any further federal criminal charges against the company based on the accident, BP took another significant step forward in removing legal uncertainty and can now focus more fully on defending itself against all remaining civil claims.

Terms of resolution

As part of the resolution, BP agreed to plead guilty to 11 felony counts of Misconduct or Neglect of Ships Officers relating to the loss of 11 lives; one misdemeanour count under the Clean Water Act; one misdemeanour count under the Migratory Bird Treaty Act; and one felony count of obstruction of Congress. This resolution is subject to US federal court approval.

Thirteen of the 14 criminal charges pertain to the accident itself and are based on the negligent misinterpretation of the negative pressure test conducted onboard the Deepwater Horizon. BP acknowledged this misinterpretation more than two years ago when it released its internal investigation report. The agreement is consistent with BP's position in the ongoing civil litigation that this was an accident resulting from multiple causes, involving multiple parties, as found by other official investigations.

The remaining criminal count pertains to two BP communications made to a member of Congress during the spill response about flow rate estimates. As part of its resolution of criminal claims with the US Government, BP will pay $4 billion, including $1.256 billion in criminal fines, in instalments over five years.

BP has also agreed to a term of five years' probation.

Under the resolution with the Department of Justice, $2.394 billion will be paid to the National Fish and Wildlife Foundation over five years. In addition, $350 million will be paid to the National Academy of Sciences over five years.

In its resolution with the SEC, BP has agreed to a civil penalty of $525 million, payable in instalments over three years.

BP also agreed to take additional actions, enforceable by the court, to further enhance the safety of drilling operations in the Gulf of Mexico. These requirements relate to BP's risk management processes, such as third-party auditing and verification, training, and well control equipment and processes, such as blowout preventers and cementing. In addition, BP agreed to initiatives with academia and regulators to develop new technologies related to deepwater drilling safety.

Report> Lisa Davison
Illustration> Mike Stones

A seismic shift

Seismic surveys are a key tool in the hunt for oil and gas, but new techniques developed by BP are transforming the speed at which data can be gathered and processed.

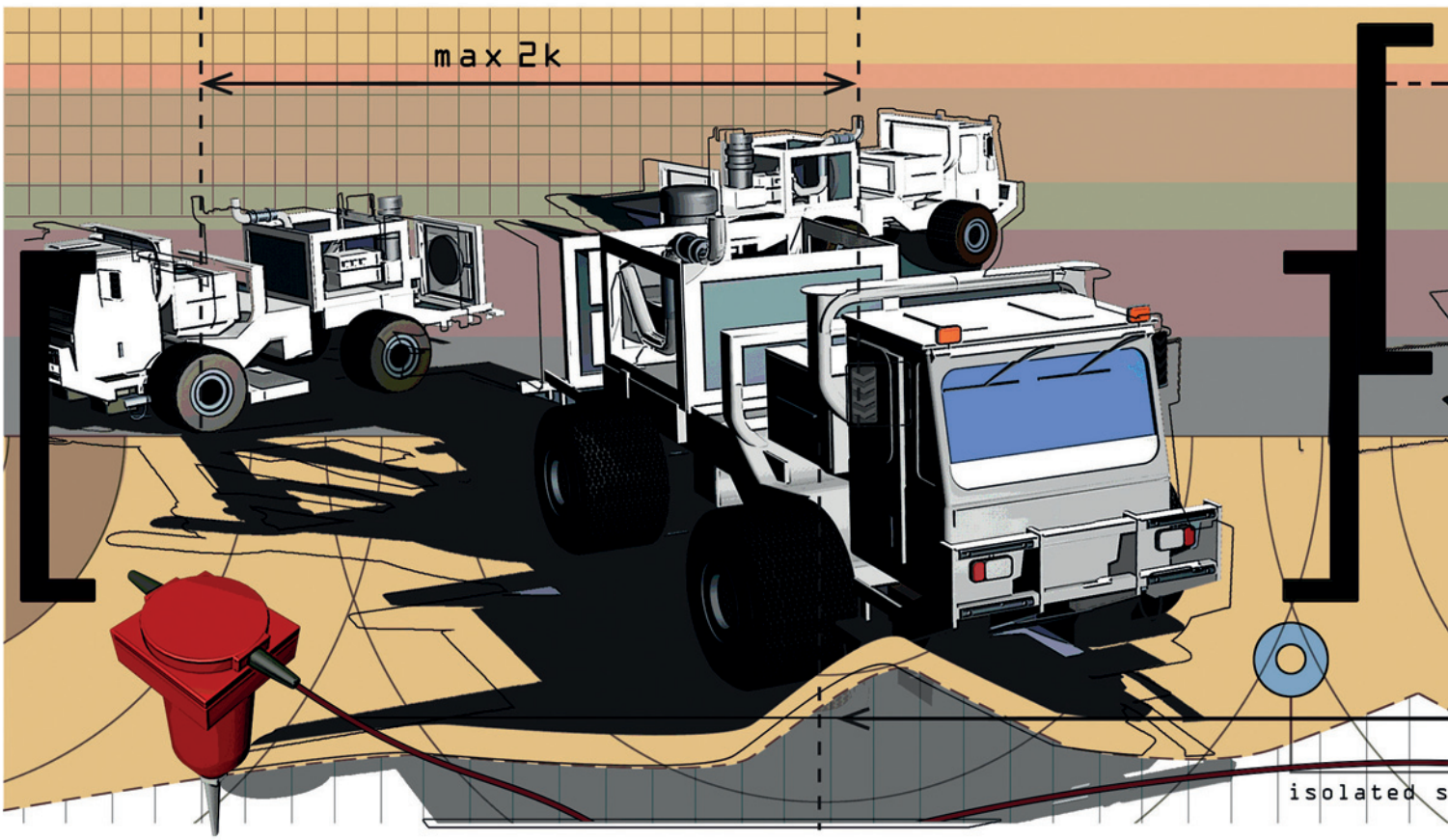
The search for oil and gas on land has come a long way since its early days in which geologists travelled on foot or horseback mapping large areas, as they searched for tell-tale oil seeps and anticlines (dome-shaped rock formations) that might hold the promise of greater deposits of hydrocarbons.

Today, geologists and geophysicists still rely on their knowledge of rock formations and mapping skills, but seismic survey technology is helping them to 'see' underground more accurately than ever before. Some of the most recent developments in this technology are having a significant impact on the way BP gathers and processes seismic data.

Seismic surveys work by transmitting sound waves through rock (if on land) or water and rock (if offshore) and picking up their reflections with special microphones known as geophones (on land) or hydrophones (offshore) which are connected by cables to a central recording unit. Those reflections are then analysed using specialised computer software.

Land-based seismic studies use a series of vibration trucks that move around the acquisition area, stopping every few metres to lift themselves from the ground, with only a metal plate to support them. The plate then vibrates, sending the sound waves down into the ground. After a few seconds, the truck sets itself down and moves to its next point.

In conventional land seismic surveys, these trucks move in rows and vibrate together at the same location, acting as a single unit or 'array'. The sound waves from the vibration penetrate the ground and are reflected back at rock boundaries. This reflected energy is picked up by the geophone and turned into an electrical signal which passes along the receiver cables to the central recording unit. The trucks are synchronised using GPS time and radio transmissions to ensure that each



vibration starts and ends at exactly the same time. This prevents any interference in the returning data. It is similar to a music concert where individual speakers are stacked on top of each other and work in tandem as a single large speaker to ensure good quality sound.

This conventional process – the industry standard for many years – is a lengthy one. An initial 'sparse' seismic sample survey (in which fewer sound waves are transmitted into the ground, bringing back a less detailed image) provides enough information for a geologist to zero in on a likely prospective area, at which point a second, more detailed survey takes place to help decide where exploration wells should be drilled. The whole process can take several years.

Since 2008, however, BP has been developing new seismic acquisition techniques that have transformed the way in which data is captured and dramatically reduced the time it takes to collect and analyse data.

One technique is called Distance Separated Simultaneous Sweeping (DS3) and allows the seismic team to acquire as much data in a single day as was formerly gathered in a week. As with traditional seismic acquisition, the vibration trucks move together in regular formation, but this time are spaced 12 kilometres (seven miles) apart. This means multiple sound waves or 'sweeps' can be carried out concurrently without interference.

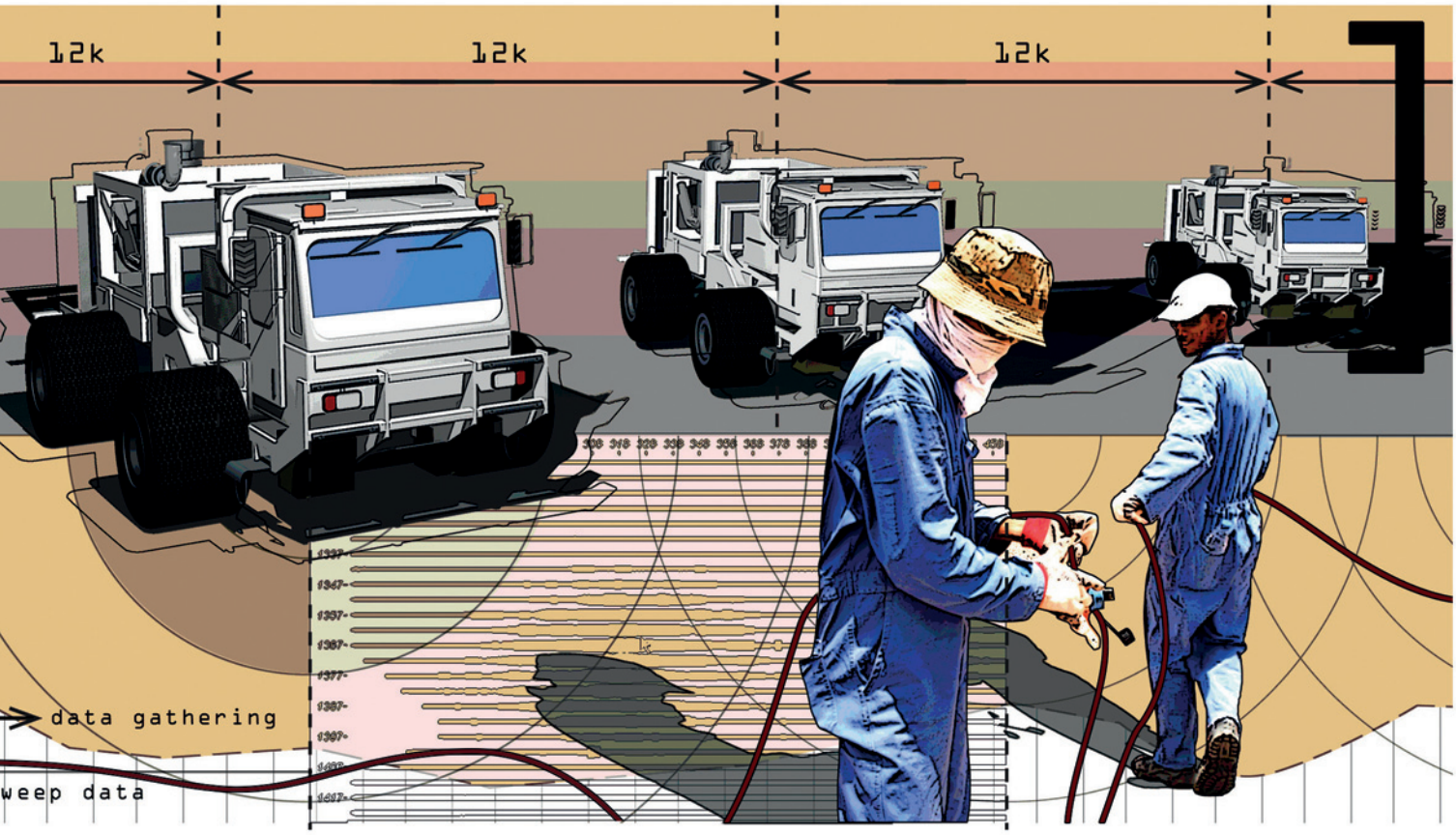
BP first developed and deployed DS3 in Oman in 2008, where it conducted a 2,800 square kilometre (1,080 square mile) survey in just five months. The quantity and rate at which the seismic data was produced, over so large an area, was unprecedented. The company has since used it to acquire seismic data across almost 5,000 square kilometres (1,930 square miles) in Jordan.

The second technique is called Independent Simultaneous Sources (ISS™) technology. Unlike DS3, the vibrator trucks are allowed to roam and vibrate autonomously. Advanced computer processing can then remove any interference between these sweeps at a later date. It's a bit like being able to isolate a single conversation you want to hear in a stadium full of people. BP developed the technique in Libya, where it had only a limited amount of time to survey a 14,000-square kilometre (5,400-square mile) area. Using the ISS method, BP was able to capture 10 times more 'shot' points every day than traditional seismic, producing the same amount of data in one year that would once have taken five.

BP has also begun to use wireless receivers to collect the data from these seismic survey techniques. Conventional surveys use grids of long cables (each up to 30 kilometres – 19 miles – in length). Receivers are then placed 50 metres (164 feet) apart along a length of cable. The cables are laid out in parallel at 500-metre (1,640-foot) intervals, the full grid could consist of up to 25 cables. However, wireless receivers can be placed at any location and use a car battery, flash card and GPS sensor to gather the data. This has significantly speeded up the process – ordinarily a survey's progress would be constrained by how fast the cables can be moved. The receivers are also having a positive impact on managing safety in the field. While cable laying can require a team of up to 15 individuals, all working on foot, sometimes in hot environments, the wireless sensors are laid by a team of two travelling by car.

Both DS3 and ISS have transformed the way that BP acquires seismic data onshore. ■

ISS™ *is a trade mark of BP Plc.*



ROCK SOLID SCIENCE

A week may be a long time in politics, but in geology, a million years is a mere moment. Geologists locate oil and gas by understanding the way the Earth's tectonic plates have shifted over millennia. *BP Magazine* looks at how that process has created the sources of the energy used to fuel society today.

Report> Helen Campbell & David Vigar
Photography> Richard Davies/Stuart Conway

Up close: Hugh Jenkyns (foreground) is a professor at the University of Oxford. He travelled with BP Libya's exploration team to study rock formations in Italy. Here, he points out the stratigraphic – rock layers – features in an outcrop. These important features may be analogous to elements within BP's exploration project in Libya.

The jigsaw-like appearance of the world map makes it fairly easy to grasp how the Earth's tectonic plates have shifted over billions of years – at least on the surface. But, for the oil and gas industry, that process has had a much deeper significance – literally.

One would be hard-pressed to find a schoolchild, even one only remotely interested in dinosaurs, who doesn't know that the shape of the continents on the globe today is not what it once was.

It's widely known that it was once possible to walk from the continent now known as Africa to Brazil without getting your feet wet, and this is why camels roam North Africa, while llamas, a very similar species, inhabit South America.

The continents we know today were once part of larger supercontinents studied by geologists and paleogeographers – ancient landmasses with names such as Vaalbara, Kenorland and Columbia.

Over billions of years, these continents and the oceans around them shifted, split and fused in numerous ways, driven by forces such as gravity and the heat emanating from its inner mantle. And for the past half century it's been understood that the pieces of the jigsaw, on which both continents and oceans sit, are the Earth's various tectonic plates.

The changes that led to today's global topography occurred between 200 and 100 million years ago when the supercontinent of Pangaea, which included most of today's landmasses, split into two continents – Laurasia to the north and Gondwana to the south – which then themselves split and changed shape (see maps on page 12).

Gondwana's different parts moved away from each other into the position of the southern continents that are familiar to us today, with the separation of South America and Africa and the creation of the Atlantic Ocean. Elsewhere, huge mountain ranges, such as the Alps and Himalayas, were formed where the tectonic plates collided with each other with nowhere else to go.

This explains why the Alpine peaks and troughs have 'African' rock in them as well as 'European' rock, and why geologists today can touch remnants of 'new' ocean floor now preserved high up in the mountains.

Despite talk of 'collisions and 'splits', these changes have occurred over millions of years. Although tectonic plate movement can cause violent events, such as earthquakes or volcanic eruptions, the plates typically move only as fast as fingernails grow – around a centimetre a year.

This is all of great interest to companies such as BP as they explore for hydrocarbons. They are constantly looking to pinpoint the most likely locations for oil and gas, so that drill bits, and exploration budgets, are targeted in the right places.

Those places are ones where certain conditions came together at particular points in geological history. BP geologist and exploration manager Richard Woodfine explains: "In simple terms, what it takes to form many types of hydrocarbon-bearing reservoir is for a hole in the ground to appear and get filled with a rich mix of plant matter and plankton which gets buried deeply and experiences elevated pressure and temperature. This creates the 'source rock', where the story of oil and gas begins. You then need a porous layer above into which the oil and gas accumulate as they naturally flow towards the surface – imagine grains like billiard balls in a triangle with spaces between them. And on top you need a seal or cap of non-porous rock to keep the oil and gas in place."

This combination of features tends to occur when landmasses are split apart. First, a hole is created, which becomes an inland lake or sea that is fed by rivers

"Our understanding of geological rifting is crucial to our understanding of how fast and how long it takes to create hydrocarbons. The knowledge about tectonic plate movement has basically driven oil exploration for the past 25 years."

Jake Hossack

and deposits all kinds of organic material as well as different types of sand and mud. This may create a stagnant, oxygen-starved, organically-rich environment. More and more sediment pours into the hole, burying the matter, increasing temperature and pressure. The sand and mud 'ingredients' become the types of rock needed for reservoirs and seals.

In the case of Gondwana, this process took place as Africa and South America started to pull apart, creating lakes, then an inland sea, then an open gulf – such as today's Red Sea – and, ultimately, an ocean. The reservoirs then clung close to the coasts of the two new continents as they pulled away from each other.

Here and elsewhere, if geologists know the characteristics of one side of an ocean, they can have a pretty good idea of the other side.

In the South Atlantic case, both African and South American coastal shelves have source rocks that geologists call 'syn-rift, lacustrine' – in simple terms, meaning 'created by rifts and lakes'.

"Our understanding of geological rifting is crucial to our understanding of how fast and how long it takes to create hydrocarbons," says Jake Hossack, a senior structural geologist at BP and former academic with 45 years in the field. "The knowledge about tectonic plate movement has basically driven oil exploration for the past 25 years."

As salt water poured into the spaces created by rifts, it would initially evaporate, leaving thick layers of solid salt in the rock formations, which, until recently, hindered efforts to find oil and gas. New seismic imaging techniques, however, have found ways to build up images of the rocks deposited before the salt was formed – 'pre-salt' in industry parlance – and unlock new provinces for production.

Combined with analysis of seismic data, the science of plate tectonics has helped BP to assess potential exploration opportunities in many regions and newly accessed countries. One such country is Uruguay, the subject of an agreement between BP and its state oil company in 2012. Most recently, regional plate knowledge has been used to assess new Australian potential and, although the full »

Practical experience: (above left) BP Libya's exploration team stands back to get a cross-sectional view of a thick section of carbonate sediments in a quarry in Italy. Above, exploration manager Richard Woodfine (foreground) and senior geologist Kuntadi Nugrahanto squeeze through a tight opening in the rock to access an important outcrop at Colma di Malcesine.

1. Middle Mississippian (340 million years)

As the Rheic Ocean continues to close, Laurasia and Gondwana move closer together and begin to assemble into the supercontinent, Pangaea.

2. Early Permian (280 million years)

The supercontinent Pangaea forms. The Tethys Ocean continues to dominate and broaden. Glaciers are present in the southern hemisphere.

3. Early Cretaceous (120 million years)

The South Atlantic continues to rift South America and Africa farther apart. India rifts away from Gondwana and Antartica and Australia become discernable.

4. Present (0 million years)

The Earth in the present configuration.

play has not yet been tested, to help inform BP's re-entry into Libya in 2007.

BP geologist Richard Corfield's work has taken him to the Himalayas, the UK and Norway and, in his current role as a renewal team leader in BP's eastern hemisphere team, to the basins of East Africa. With any basin anywhere in the world and before any data is available, Corfield says, the first thing BP's teams have to go on is regional-scale plate reconstruction.

"We look at where the plates were in the past and, critically, when the basins started to open, using that plate tectonic information," Corfield explains. "We correlate our global knowledge onto those maps to try and predict the places where we think there will be a better chance of there being good source rock. This is the first step of describing what sort of setting a basin would have occupied at the time sediments were deposited."

Determining the time when ocean-spreading occurred and when sediments were deposited will indicate the likelihood, or otherwise, that a basin has high organic content preserved and, therefore, presented the right conditions for hydrocarbon formation.

The process of global change continues, with some of the most dramatic rifts now taking place in east Africa as tectonic plates break apart in a similar way to those of Gondwana more than 100 million years ago. Today's lakes may be the seas or oceans of a future age and already oil companies have started to look for oil and gas in east African reservoirs that are only 1 or 2 million years old – as opposed to the hundreds of millions typical of reservoirs such as those in the South Atlantic.

Looking at history on a geological timescale is a reminder that resources that took millions of years to form have been found, produced and consumed in a matter of centuries. In a few decades, the pattern may change again. The world is using energy more efficiently – with decreasing volumes of energy needed to create each unit of wealth – and non-fossil energy expected to grow faster than any single fossil fuel. But as long as oil and gas are required to power a major part of society's growth and development, geologists' growing understanding of the Earth's complex history will be critical in showing where they can be found.

THE MATHS BENEATH THE MANTLE

The phenomena of the spreading of the sea-floor, magnetic anomalies and the role of earthquakes were finally joined up in the 1960s by one of two men credited with the 'final' breakthrough on tectonic plate movement. Professor Dan McKenzie, then a University of Cambridge PhD student.

McKenzie published a renowned paper in 1967, explaining the mathematical model behind convection in the Earth's mantle and thereby the movement of its crust. Within the sphere of Earth science, his findings had an impact that was comparable to that of understanding the structure of DNA on biology, and changed our view of the Earth forever.

Professor McKenzie has worked closely with BP in a consultative capacity for many years and, while he will continue to teach, retired from the Chair towards the end of 2012. Amidst much looking at maps and globes and some nifty paper-sliding techniques, *BP Magazine* interviewed him about the impact his discoveries had in the 1960s.

Is tectonic plate movement as complex as non-geologists fear?

Tectonics is the easiest part of geology to understand; it is all geometric, and the most astonishing thing about it is that it is taught in primary schools. It is an extremely simple notion, once people understand that this is about motion on a sphere, not on a plane. The Earth is spherical, so the plates move on the spherical earth. When we first started teaching it, we used National Geographic globes to show the undergraduates the rotation of the plates and get them to reconstruct it.

Your 1967 paper described this for the first time. What did people previously believe?

That's the question that every undergraduate asks and it's easy to answer

– we had no understanding of what was going on whatsoever. It wasn't that we didn't know how the plates moved, because we didn't even know there were plates. The idea that the South Atlantic was formed by separating Africa from South America goes back years, but the difficulty was that it was a rather woolly notion and no one could actually do anything with it. The early idea up to the 1960s was that the continents ploughed through the oceans like icebergs. Once we started looking at the oceans, we could see that was nonsense because the sediments coming up to the continents were absolutely flat and it made no sense.

Close reading: Professor Dan McKenzie (bottom) was one of the two men credited with the 'final' breakthrough on tectonic plate movement, having published a paper in 1967 explaining the mathematical model behind convection in the Earth's mantle and, therefore, the movement of its crust.

What was the initial reaction to your paper, of both academia and the oil industry?

I did this when I was 25, and I was quite clear that I was right and everybody else was wrong. I probably came across as extremely arrogant and made a few enemies. Particularly in the States, these ideas were really objected to, to the degree that if you believed in the mobility of the continents, you couldn't actually get an academic job. There was just a very small number of outfits, so this department and departments at Princeton and Toronto, where people did believe this. The oil industry, including BP and Shell, absolutely dismissed the whole show, saying; "No, this does not happen."

How did those reactions change?

The theory has not budged since 1967, but it did take probably another 10 years for this to become a part of every undergraduate course around the world. Even here at Cambridge, I spent a lot of committee meetings in the 1970s struggling to get plate tectonics talked about to the undergraduates. I finally got two lectures a week in 1977, but when I went on sabbatical, they removed them! It happened very, very suddenly when the next generation of graduates went through and joined oil companies and educated their bosses that this was absolutely central to geology.

Was it the last piece of the geological jigsaw, or a whole new piece of understanding?

Not really either, but it made the whole thing clean. By the 1960s, we understood earthquakes, we understood volcanism, we understood plates, and that magnetic anomalies had reconstructed the oceans. We still did not understand exactly what caused the plates to move, but there was a sudden, universal acceptance that they did move in the way I was describing, and that there were geological rules about their movement.

Did you still encounter outright scepticism?

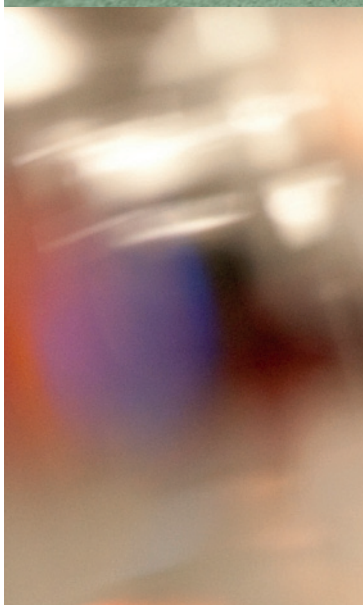
As a scientist, once I know I've got something right, I lose interest! With plate tectonics, I was not in any way interested in trying to convince people that this was right, I just felt they should go away and read what had been written. Without it, I felt their whole understanding and ability to understand where to find oil was up the creek. In the late 1970s, I was based in the US, and the most influential geologist at Shell at the time asked me to come to Houston and deliver a talk on my ideas about sedimentary basins. "But," he warned me, "nobody in your audience believes in plate tectonics, so be a little bit diplomatic."

How has tectonic science affected the oil sector?

One of the really puzzling things about sedimentary basins is that the North Sea, for example, has about five kilometres (three miles) of sediment, and the oil is down at the bottom. All of this sediment was deposited in shallower water, so why has it gone on sinking? Working in Greece and Turkey, looking at the present-day motions that are causing earthquakes, it suddenly dawned on me that the whole of the Aegean was being stretched, and if you stretch a rigid plate, it gets thin. What then happens is that the hot mantle of the Earth comes up and fills the hole, then it cools and shrinks and that is how sedimentary basins are formed. This work told us two major things; how fast the basin goes down, and the temperature. Being able to understand how the source rock matures and produces oil was absolutely fundamental to the oil business, and it became the woodwork of the whole sector. I am absolutely delighted about the economic use that has been made of my ideas. The use that companies make of scientific ideas seems to me to be the reason we can all live in the comfort that we do and I am extremely pleased to have been a part of that.

There is still a lot we don't understand about the Earth. If you could only fathom out one more puzzle, what would it be?

The one thing you can absolutely guarantee about scientific research is that it will go off on its tangents, and you never know what those tangents are going to be. There are things we can do now that we could not have conceived of. I would love to understand how the West Siberian basin was formed, and we don't have the slightest idea what went on there. West Siberia is missing the geological faults that other basins have that show us where the break was, and that is the big conundrum. You can never say never with science, because you just do not know where things are going to go. ■



Broad view: (from top) view of BP's Atlantis platform, Gulf of Mexico, US, from the helideck; onboard BP's Greater Plutonio FPSO offshore Angola; and at work on the East Azeri platform in Azerbaijan's Caspian Sea.

A DISCIPLINED APPROACH

Running BP's upstream operations is not a job for the faint-hearted. From the production facilities themselves to the equipment that exports hydrocarbons in a way that is safe with minimum impact to the environment and disposes of the water used to extract them, BP's Operations team is responsible for making sure that all the equipment used to produce, contain and transport oil and gas works safely, reliably and efficiently.

Report> Martin Thomas **Photography>** Marc Morrison/Richard Davies/ Stuart Conway/Rocky Kneten/Simon Kreitem/Chris Moyse


SonAir

Regular delivery: a supply boat pulls up alongside the Chirag platform in Azerbaijan's Caspian Sea. The yellow triangular transport is known as a frog and lifts personnel from the supply vessel up onto the platform.

As a global operator, BP oversees an extraordinary number and diversity of facilities – from liquid natural gas plants in Indonesia to giant floating production vessels off the Angolan coast; from working in a complex consortium at Rumaila in the Iraq desert to BP operations in the permafrost of Alaska.

The Operations function starts with BP's operators in the field and extends to the office-based staff who support them: the engineering teams who solve technical issues, the logistics teams who coordinate the boats and aircraft needed to transfer operators to and from facilities, the planning teams who ensure that any work done at the facilities is properly scheduled, and the reliability teams who maintain the equipment so well that defects can be anticipated before they occur.

There are around 9,000 people in BP's operations team, split roughly equally between the operators and technicians on the ground and those supporting them from offices around the world. There are also around 2,000 contractors engaged by BP, as well as more than 12,000 suppliers – providing personnel and essential goods and services to keep operations running smoothly.

In March 2011, upstream Operations in BP became a global function. This meant that all operations specialists, all over the world, were brought together into one team that could be managed as a global unit of professionals. The man charged with leading the function was Fawaz ('Fuzzy') Bitar.

Bitar says: "I believe the functionalisation of Operations is a step forward in our efforts to continue enhancing safety, and making us more efficient and more standardised. We now have a strong central team that includes vice presidents for reliability and maintenance, for subsea operations, for engineering services, for logistics and for all the key functions that are required to manage operations.

"We've gone out of our way to build a very strong team, pulling in some of the best BP people from the regions and also looking externally to hire people who will give us a fresh perspective. For example, our vice president of reliability and maintenance was at Exxon for 17 years, »

and our logistics vice president – a position we've never had in BP before – is a pure, professional logistician.

"The central functional team works closely with the vice presidents in the region, whose job it is to do the day-to-day running of all operations in their regions. The central team is more focused on building overall functional excellence over time."

Bitar is still building his core team and says this process will continue until the end of 2013, but, although he uses the future tense when he talks about the positive effects of centralising the operations function, there are already clear signs of improvement.

Bitar says: "We've put in place a number of metrics that tell us we're getting better in many different ways. In personal and process safety, plant integrity, planning, plant efficiency."

Bitar says these metrics are essential because they highlight so-called 'weak signals' – small variations in outcome that can signify important changes – either positive or negative. And sometimes the metrics are more definitive.

"For example, we saw a significant drop in the number of process safety incidents for the Production division for the first half of 2012 versus the first half of 2011 and our plant efficiency is improving over time," says Bitar. "This gives us confidence that we are working to the right agenda and I'm encouraged by the results we're beginning to see."

Plant efficiency is perhaps the most straightforward of all the operational performance measures. If a plant runs uninterrupted for 100 days, it is 100% efficient. Interruptions can be planned – such as maintenance turnarounds – or unplanned – such as stoppages caused by incidents or breakdowns. There have been some remarkable plant efficiency improvement success stories around BP's upstream operations in recent years.

In Angola, plant efficiency was running in the fifties in mid-2011 and has risen into the nineties in 2012. At Tangguh LNG in Indonesia, and at the Schiehallion field in the North Sea, the numbers are also impressive, with material improvements when comparing 2012 against 2011.

Bitar says: "We have a number of fields where we've been particularly focused on improving plant efficiency and in those fields we improved it by 5% between January and August 2012, compared with the same period in 2011, which is a big number. The biggest contribution to that success was everyone at the facilities focusing on systematic defect elimination, which means really understanding what's causing facilities to shut down and then fixing it so it never occurs again."

> "The single most important factor is people – having the right people onboard who are properly trained, competent, respected, and listened to. It's our people who bring the equipment to life."
>
> **Fuzzy Bitar**

It took more than merely centralising the team to bring about the improvements BP is beginning to see. Bitar is clear on the priorities. He says: "The single most important factor is people – having the right people onboard who are properly trained, competent, respected, and listened to. If you have a workforce with good, healthy relationships with management,

Taking the lead: (from left) head of operations Fuzzy Bitar talks with Melissa Mark, area operations manager for Greater Cassia, during a BP Trinidad and Tobago site inspection; a control room technician checks the metering readings for Bruce gas production streams; workers onboard the Thunder Horse platform, Gulf of Mexico, US.

you are setting yourself up for a very strong operation. It's our people who bring the equipment to life.

"Having a management system that clearly sets out the standards to which we must work is essential in any high-hazard industry. It's also about our behaviours – running a disciplined organisation with the right culture.

"Our equipment is very important, too. We must take care of everything we use; we inspect it, we maintain it properly with a view of predicting defects before they occur."

Bitar has set out five continuing priorities for his team in the coming three-to-five years: embedding the functional model; eliminating defects by improving maintenance; managing process safety and plant integrity – making sure BP people are safe and the equipment they use is in good shape; focusing on control of work – so that work is always executed in the safest possible way; and driving behaviours of compliance and discipline – developing the culture of operations.

He says: "It's essential that we become systematic in everything we do. So, let's say we have a maintenance management system that dictates we test certain equipment at a particular frequency. Being systematic means that this work is always done, it's done on time, it's checked and verified that it meets performance standards, and our systems tell us it's been done properly. Being systematic is a combination of process, leadership and behaviours. It means repetitive, consistent, predictable outcomes."

Becoming a global organisation carries with it the obvious risk of upsetting the regional teams, who may be perfectly happy with the way they did things before. But there appear to be no such tensions on speaking with Bitar's vice presidents from the regions.

One of them, operations vice president in Angola Fernando Guitart, says: "It's made my life simpler, actually. Our priorities are very clear: we need to fully understand the risks in our operations, be systematic in the application of our management system and be disciplined and rigorous in our approach. Our previous model tended to be complex in structure and local in nature. This meant we tended to develop local solutions to challenges, with people's expertise staying within the asset.

"But the functional model gives us all access to the global resources and lessons that we can easily share across the whole »

organisation, allowing people to be really focused on the task at hand – and when we're sharp, clear and focused, we can do great things together."

Guitart has taken advantage of the new model to bring about major reliability improvements at the Greater Plutonio field off the Angolan coast. Among the challenges his team addressed with the help of the global team was corrosion associated with the high-pressure gas compressor coolers and the water injection discharge pipework. Both issues resulted in the plant having to be taken offline for inspections and caused a fall in production.

Guitart says: "These two issues were having an impact on reliability at Greater Plutonio, so we got a cross-functional project team together with help from our global functional colleagues. Thanks to the expertise at our disposal, we clearly understood the root cause of the defect and that enabled us to get the right people and the right plan in place to sort it out."

Bitar takes a holistic view of operations. He believes that safety and production are two sides of the same coin. He says: "I don't think we should separate safety from reliability at all; they go hand-in-hand. I firmly believe that a reliable plant is a safe plant. If you have a reliable plant, it means you're not shutting down so often and your plant is more stable and thus more likely to be safe. If we continue to focus on the things that drive a reliable plant, like defect elimination and risk reduction, then we will get two things: more production and a safer plant."

Vice president of offshore operations for Azerbaijan, Georgia and Turkey (AGT) Mark Thomas agrees: "Safety incidents can really distract our crews. There's a clear correlation between the number of safety incidents and reliability. It's a vicious circle because if you have safety

"I don't think we should separate safety from reliability at all; they go hand-in-hand. I firmly believe that a reliable plant is a safe plant."

Fuzzy Bitar

incidents, you have to investigate them, which distracts the crew from what they're normally working on. If the crew loses concentration, then you have trips [where safety systems override operations and shut down equipment]. You were investigating a safety incident, now you're investigating why you have this downtime, so you're constantly going back and forth between fire-fighting and fact-finding."

Thomas is keenly aware of the problems of 'downtime', given the scale and scope of the activities under his control. Offshore Azerbaijan, there are around 1,000 people working on six platforms. Five of these are in the Azeri-Chirag-Guneshli oilfield, one of the largest offshore fields in the world, and the sixth is the Shah Deniz gas platform. These six platforms operate all day, every day, year-round and the oil is transported through a network of subsea pipelines to the Sangachal terminal, which is one of the biggest terminals in the world.

Thomas says: "Our intention is that we should operate every single day safely and reliably. If something happens that wasn't supposed to happen, we investigate it, we find out what the root cause was, and then we put actions in place to prevent it from happening again."

Thomas is dedicated about driving down safety incidents – whether they relate to people or equipment – and thus improving reliability. He says: "In the first three months of this year, we had three people hurt working on our platforms, which was unacceptable. They weren't major incidents: one person tripped over a protruding piece of metal on a deck and sprained their ankle; someone else hit their forehead on an open door. We work in a hazardous environment, but people weren't getting hurt by hanging overboard to carry out inspections, they were just getting out of bed or going to the shower. But still, these incidents are not supposed to happen. So we talked to the crew to figure out what was behind these niggling injuries.

"What we found was that people sometimes had personal concerns on their minds. So, we decided to make sure that everyone coming offshore had their mind in the right place. We talked to them and said 'if you've got some personal matters you're bringing onboard, talk to us; we can't have you working for us and worried about what's going on at home. Tell us and we'll try to help.'

"The offshore installation manager [OIM] is the leader on any platform – he or she is basically in charge and accountable for that platform. Now, the OIM greets every single person coming onboard, sits down with them and has a short discussion about what's happening on the platform, what's on their mind, and this is my expectation: when you're here, you will do this, this and this."

Thomas insists on a similar attention to detail when it comes to process safety. He says: "Our top priority is to make sure the hydrocarbons we're producing stay inside the pipe. Our technicians are constantly on the look-out for leading indicators that suggest things aren't doing quite what they were doing yesterday – a pipe that seems to be vibrating a little bit more today, or a small weep on valve packing. They're not big things, but any one of them could escalate and become a reason for hydrocarbons to escape from the plant.

"Our technicians have taken up the challenge of not allowing anyone to get hurt and they're taking the same approach to the kit. They say 'this pump is my pump and I'm going to make sure it runs the way it should. I'm going to take care of it and nurture it. If it's supposed to last for five years, I'm going to treat it like I want it to last for 10.'

"As a result, we've had no injuries since March. We generate about 1 million manhours a month offshore and our recordable injury frequency rate for offshore operations is about 0.13, which compares to the industry average of 0.352. That's very encouraging."

The benefits brought about by the team's scrupulous nature are not going unnoticed in the wider industry. Thomas says: "We're running at around 97% plant efficiency, which is top-tier performance. So, we benchmark very well."

It's easy to forget that the new global functional organisation has been in place for a little more than a year-and-a-half. So much has changed in that time. But there remains a great deal of work ahead, according to Bitar. He says: "When you make the kind of changes we've made to an organisation of this size, there are inevitably issues that need to be addressed as we embed the new structure and way of working. We're going to keep working on them – systematically – until they go away.

"I can feel the momentum building and it feels increasingly as though the whole team is united behind a set of common objectives and milestones. And when that happens, we can have confidence that we will achieve our goals." ■

Global perspective: (clockwise from top) a maintenance team leader conducts a toolbox talk with team members before an activity at the Greater Plutonio FPSO in Angola; personnel in the local control room at BP's liquefied petroleum gas plant in Tangguh, Indonesia; BP's Jayhawk natural gas liquids plant, part of its North America Gas business; and operations personnel prepare for a lift on the West Azeri platform, Azerbaijan, the foreground is the 'frog' and in the background the platform's drill derrick and exhaust stack.

Big business: the Flat Ridge 2 wind farm in Kansas will be the largest single-build wind farm in the US, generating 470 megawatts of renewable energy that will be exported to customers in neighbouring states.

ALTERNATIVE HARVEST

In just six years, BP has gone from zero wind capacity to having almost 1,500 turbines spinning across the US and being one of the country's top-five wind power generators. *BP Magazine* finds out more.

Report> Leslie Viney
Photography> Marc Morrison/
Douglas Benedict

Multiple states: (from left) workers at the Mehoopany wind farm in Pennsylvania do morning exercises; sunset over Cedar Creek 2, located in Colorado; aerial view of wind turbines in the Mehoopany wind farm.

Flat Ridge 2, Mehoopany and Auwahi: three wind farms that will be transformed from building sites with evocative names to some of the most groundbreaking wind projects BP has undertaken.

Located in Kansas, Flat Ridge 2 will be the largest single-build wind farm in the US, generating 470 megawatts (MW) of renewable energy, all of which will be exported out of Kansas to customers in neighbouring states. Meanwhile, Mehoopany in Pennsylvania will deliver power from a 9,000-acre-mountain site, which required construction of 50 kilometres (30 miles) of new roads to move approximately 880 turbine components along road gradients of 14%. Auwahi, an eight-turbine site on the southern coast of Maui, Hawaii, will tackle the island's perennial problem of intermittent wind power and grid stability with a battery storage unit that holds more than four megawatt hours of electrical power.

Once online, these three challenging projects will bring BP's wind farm portfolio total to 16, located across nine states, all of them achieved in just six years, from the initial purchase to a portfolio of development projects.

BP is now the fifth-largest wind power producer in the US market, with a $5 billion portfolio, almost 1,500 turbines spinning and by the end of 2012, a total energy generation of 2,600MW. "That's not a bad place to be," says John Graham, president and chief executive of BP Wind Energy. "We are punching above our weight and I'm very proud of what the team has achieved in such a short space of time."

Regardless of its location, each project requires all BP Wind Energy's operating units to work together to undertake the development, build and operation. At the front end, senior vice president and chief development officer Larry Folks oversees the development process, from finding the prospect and acquiring the land, to completing the environmental work, analysing wind resources, arranging permits and clearances, contracting to sell the power and finalising all other major contracts.

He explains: "The development period is much longer than the construction period; it can be two years in development and just six to 12 months in construction, unless you have significant civil and terrain issues such as a mountain ridge location or the need to build roads."

If BP is partnering on a project, as it has done with Sempra on five separate occasions and with Dominion and NRG on two others, Folks and his team will arrange the partnership and work with BP's treasury group to arrange project financing.

The Flat Ridge 2 wind farm required almost $900 million in capital and has its own private generation tie line connecting it to the main grid. The idea came from BP's development team to speed up the process.

Folks says: "We found a point near Wichita located 65 kilometres (40 miles) east where we could immediately connect to the grid without waiting for new utility transmission upgrades, and so we sent out our people to arrange for a transmission right-of-way. There were a lot of parcels of land – 90 landowners from whom we had to get permission in order to build the transmission line – and we got a clear path to the big power lines to the east."

From there, the team was able to go straight to the market and sell its power under a power purchase agreement (PPA) to three out-of-state utility companies. "It also meant we could keep scaling up the project," says Folks. "When we got another customer interested in buying more power, we made the project bigger, which gave us better economies of scale and made the project more competitive."

Once a project is sanctioned, it moves into the detailed engineering and construction phase under Kimberly Randolph, BP Wind Energy's vice president for projects and development engineering. With four completed projects, almost 500 turbines and 850MW of wind power under her belt, Randolph and her team engage contractors to support the detailed engineering packages, including electrical and geotechnical studies. Approximately six to eight months later, the groundwork for the project is laid and the team transitions into the execution phase and begins mobilisation to the construction site.

At Mehoopany, BP managed the transportation and delivery of 88 turbines from 11 locations across the US to the 9,000-acre site located 30 kilometres (20 miles) northeast of Scranton, Pennsylvania. To transport the turbine components along steep grades on the mountain, special heavy duty vehicles were employed for approximately 500 super loads weighing up to 73 tonnes (146,000 pounds).

"During construction, special care is taken to protect the environment and habitat areas within the project footprint. For example, we had to protect rattlesnakes

in the area and ensure we didn't have an adverse impact on the rattlesnakes' gestation, basking or denning habitats," says Randolph. "That required local biologists to visit the construction area before construction crews went in. It's all about respecting the environment and the critters, large or small."

Maintaining a positive relationship with the community is essential to a project's success. "Before we mobilise onsite to commence construction, we'll have a series of community events where they have the opportunity to ask questions. We'll show pictures of general construction equipment that can be expected on a typical wind construction site. Then, at periodic intervals or at significant milestones in the construction phase, we'll engage with the community. During construction, there's always a member of the team for the landowners to call."

Carol Voran, county commissioner for Kingman County, one of the four counties in which Flat Ridge 2 was built, says that despite this being the first wind development in her county, "the fact that oil and gas have helped this county for 40 years helped bring residents on board."

One landowner, Elaine Watson, whose farmland is in nearby Harper County, was 'thrilled' to learn that she would be given two turbines on her land. "I only have 160 acres, which I rent out to a farmer to grow wheat and graze cattle. The extra income is helpful."

Watson says that BP also improved roads to her farm. "Before, you couldn't get a car down. The BP representative gave us his card to keep us informed and if we had any concerns. My farmer and others say the team has been courteous with driving and gives them the right of way."

Voran is equally impressed. "We negotiated a payment in lieu of tax agreement [PILOT] and the money has gone into a general fund. The economic benefits have been huge. With 500 people employed on the project, they've filled up the rental homes, so there's money for individuals and the sales tax increased with their purchases.

"In addition, they've provided the fire department with added equipment, have attended country fairs and hosted community meals to get to know some of the people they're leasing land from and the political entities. They've even brought a turbine blade in for signing."

Once the turbines are up and running on a site, the operations team, directed by Jonathan Roumel, takes over accountability and ownership of the wind farm. "We help to maintain and operate the site for its full lifetime – we'll have our personnel onsite for 20-plus years."

Given this long timeframe, the long-term safety and efficiency of a wind farm »

"We are punching above our weight and I'm very proud of what the team has achieved in such a short space of time."

John Graham


Ford

Wind in the US:

2.5 gigawatts
The amount of power under BP Wind Energy's operations

16
The number of wind farms in BP's portfolio

50 kilometres
The amount of new roads BP constructed to build its Mehoopany wind farm

90
The number of landowners BP needed to get permission from to build Flat Ridge 2

Perfect conditions: the Cedar Creek 2 wind farm is located on a 30,000-acre site and has a generating capacity of more than 250 megawatts.

is critical, and like the rest of the company, BP Wind Energy uses BP's operating management system to identify risks and gaps as well as build on positive performance.

According to Roumel, this involves "safely generating renewable power for our customers, and maximising efficiencies and revenue generation across the fleet. If a component is faulty, we want to be able to identify it at each site, assess the impacts to ensure we can prioritise our focus and accomplish our goals."

While personnel onsite carry out spot checks on the equipment, a fully-manned remote operations centre, located in Houston, tracks the turbines at every site and flags any issues that need immediate action.

At the moment, BP manages all of the wind farms, except for the turbines, which are maintained by contractors from turbine suppliers, such as GE. With the first of BP's five-year agreements with contractors about to expire in 2013, Roumel and his team are considering the best way to run the wind farms in the future.

Roumel says: "We're looking at safety, economics, control and seeing the plusses and trade-offs of each option. By the end of 2012, with almost 1,500 turbines and more than 2.5 gigawatts of power under our operations, we have reached a critical stage where we can maximise efficiencies and standardise processes to also capture best practices from a broader fleet of operating assets."

One simple change that has now been introduced is the onsite storage of high-value, low-cost spare parts for turbines. This reduces the amount of downtime, or having to source alternative options in case stock from regular suppliers becomes unavailable.

Every quarter, all those involved in the wind projects – including engineers, project managers, support staff and developers – meet to discuss and learn from each other. These best-practice sessions are written down, and handed to the project manager to incorporate on the next project. "This really confirms that we are capturing the lessons learned and that we are applying them," says Randolph.

One current issue having a potential impact on the growth of the business is whether the US Congress will renew the production tax credit (PTC) for the coming year. In a recent speech to the Kansas Renewable Energy Conference, Graham urged Congress to get behind the PTC, introduced in 1992 by the Federal Government to provide a 2.2-cent per kilowatt-hour tax credit for the first 10 years of electricity production from utility-scale wind turbines. Until the renewal is approved, new development plans for 2013, including Flat Ridge 3 located west of Wichita, Kansas, are on hold.

Folks is quietly optimistic that the PTC will be extended and in the meantime, the development team is keeping its eye on the prize. "We're working harder than ever," he says.

Uncertainty aside, BP Wind Energy's president remains committed to further development. "I know that wind energy is making a valuable contribution to the energy supply," says Graham. "We were pioneers of oil and gas and we are building a legacy of alternative energy sources. This is what makes me passionate about this business and why I am with BP which supports growing the sources of energy available in the world." ■

Remote operations: (below) BP runs a remote operations centre from Houston that tracks the wind turbines at every site and flags any issues that need immediate action. Bottom left, the Flat Ridge 2 wind farm required almost $900 million in capital and has its own private generation tie line connecting it to the main electricity grid.

"I know that wind energy is making a valuable contribution to the energy supply. We were pioneers of oil and gas and we are building a legacy of alternative energy sources."

John Graham

Photography> Rocky Kneten

GOING COASTAL

Samuel Walker / group marine science expert

"The coastal zone is one of the most fascinating areas on the planet," says Samuel Walker, group marine science expert. "It's a rich environment in terms of its ecosystems and it's the first line of contact between the world's oceans and a large part of the planet's population."

Since joining BP's environment, social responsibility, and HSSE compliance team in 2011, Walker has worked to strengthen the company's capabilities to monitor and understand marine environments where BP operates offshore around the world. "Our primary responsibility is to identify and develop strategies to minimise risks for our operations. It's a responsibility that everyone on the team takes very seriously."

Walker's background is a blend of operational research and applied science in environmental health and coastal ocean ecosystems issues. He has worked for organisations in the non-profit and private sectors and for the US government, including managing regional ocean observing programmes for the US National Oceanic and Atmospheric Administration (NOAA).

Walker says he was motivated to join BP because of the company's commitment to using science to better understand the oceans and coastal zone ecosystems. "There is a tremendous opportunity to advance the science and technologies used to better monitor marine ecosystems and to develop programmes to mitigate risks to the environment and our offshore operations. This was a chance to apply my science skills and experience in coastal zone ecosystems in an area that I believe can have a positive impact." ■

Samuel Walker is pictured here on the Gulf Coast carrying a small-scale autonomous ocean vehicle (AOV) – a tethered, submersible robot which can host a range of sensors and instruments. This model hosts an underwater camera system that can monitor and photograph the marine environment.

Photography: Aaron Tait

Rolling stock

In a state four times larger than Texas and 20 times bigger than England, driving distances in Western Australia are often too vast to justify transporting freight by road. Railways allow industries to move larger quantities of goods faster. At BP's Kewdale terminal in the state capital, Perth, up to 20 rail cars are filled with fuels on a daily basis. Locomotives and their freight travel almost 600 kilometres (370 miles) east to BP's terminal in Kalgoorlie-Boulder. Some 800,000 litres a day of diesel alone then continue their journey by road, to supply industrial customers in the resource-rich Goldfields-Esperance region. Other products – including regular unleaded, the advanced performance fuel, BP Ultimate, and the low-aromatic fuel, OPAL, designed specifically to discourage petrol-sniffing in remote communities – are also supplied from this terminal. See the next issue of *BP Magazine* for more on BP's upstream and downstream businesses in Australia. ■

Report by Amanda Breen

On track: Kalgoorlie-Boulder terminal manager Glenn Anderson prepares an operation to unload fuel from a rail car.

Report> Martin Thomas
Photography> Richard Price/Stuart Conway/Kjetil Alsvik

INTELLIGENT ENERGY

Over the past decade, BP has made great progress in applying digital technology to its oil and gas production, providing the company with a raft of real-time data to help reduce operational risk, optimise production and work more efficiently.

Joint effort: at work in one of BP's 35 advanced collaborative environments (ACE), UK. By connecting different locations and assets with real-time monitoring technology, ACEs brings the right information to the right people, at the right time, allowing real-time, multi-disciplinary decision-making to support drilling and production operations.

For an oilman, Steve Roberts talks a lot about cars and aircraft. That's because his job is to help BP and the energy sector catch up with the auto and aviation industries in using computing and digital technology.

He says: "There are parallels to draw between the oil industry and the car-making and aerospace sectors. Both used to be purely mechanical, but both are now heavily computerised. Modern cars and aircraft are full of real-time monitoring and optimisation systems – and are much safer and better performing as a result.

Roberts's particular focus is applying digital technology to optimise the production of oil and gas. As the head of BP's *Field of the Future*® technology flagship programme, he is responsible for finding ways to gather and use digital information from wells and reservoirs in real time to help BP reduce operational risk, improve reliability, optimise production, and work more efficiently.

Roberts and his team aim to give BP's upstream its own variant on '20-20 vision' by targeting the year 2020 as the date by which digital systems will not only be gathering vital performance data, but also, in many cases, automatically taking the actions needed to keep operations safe and efficient through the use of 'intelligent agents'.

BP has come a long way on its digital information journey in the past decade, says Roberts, but still has a long way to go.

"I would say we are about a decade into a 25-to-30-year journey applying digital technology to provide relevant information in real time – some way »

Office to offshore: inside BP's ACE (above) at its offices in Sunbury, UK. Below: an aerial view of BP's Skarv floating production storage and offloading vessel on tow through a Norwegian fjord. Skarv has cutting-edge real-time technology integrated into its design.

"Historically, our industry has not had to rely on digital information to help produce oil and gas. But as key skills and resources get scarcer and exploration and recovery get more difficult, efficiency has become a more significant driver."

Steve Roberts

behind car and aircraft manufacturers – and I think there are clear reasons for this. The main one is that they are constantly building new products and can, therefore, install the latest versions of technology. In the oil and gas industry, we have a huge legacy infrastructure to retrofit – and, in many instances, this work would have to be done under incredibly harsh environmental conditions.

"Historically, our industry has not had to rely on digital information to help produce oil and gas. But as key skills and resources get scarcer and exploration and recovery get more difficult, efficiency has become a more significant driver."

Roberts sees a shift of emphasis ahead, as the boundaries of digital technology are pushed forward: "We're putting lots of effort into making systems more straightforward and informative at the front end so there's less complexity evident to the end user – but that requires lots of work behind the scenes. It also requires different skills – where in the past we might have focused on core exploration and production disciplines, now we're also interested in things like decision analytics and information engineering skills.

"Think of it in terms of modern jet fighter cockpits – they're much more sophisticated than they used to be even a few years ago, but the display the pilot looks at is less cluttered than it was. The great thing about the aircraft and car industries is that they've learned how to integrate all of the information they gather into a pretty small footprint, called a dashboard or a cockpit. Neither has grown in size over the years, but compared to 30 years ago, the amount of information available through the dashboard or cockpit has grown phenomenally.

"Both used to be full of mechanical dials; now, everything is computer graphics. I've just bought a car that only shows me the information I need when I need to see it. It'll highlight problems as soon as they occur, but for the vast majority of the time, I don't even know it's tracking data and processing it.

"Compare that with a car I bought three or four years ago. It had some of that integrated information in the dashboard but not all of it, so I started adding gadgets to my windscreen, which soon started to look cluttered. That's where we are in the upstream industry at the moment. We're adding screens to our operating centres – some of our operators are looking at 30 screens. The car industry has moved on so you don't have to buy gadgets any more – everything's already integrated and that's the next part of the journey for us."

One of the big challenges facing BP people is adapting quickly to the new digital age. "Some of our operators have worked in oil and gas for 30 years," says Roberts, "and suddenly they're being asked to trust advice from information systems or rely on automated systems. But the next generation coming through will be expecting those sorts of systems and will be much more comfortable using them – just like they already use them for communication in their daily lives, for example."

Predicting how the oil and gas industry will be operated in 10 or 20 years' time is not an exact science. Roberts says: "Some things will not change – we will still have to drill holes to discover and recover hydrocarbons. However, the way we control and optimise the performance of plant and well systems will be radically different. We will use interfaces that are scarcely imaginable today, richly analysing data from monitoring all aspects of plant and well operations, and converting it into predictive information that allows the automation of some processes and enables engineers to handle the rest much more efficiently."

BP's real-time information journey starts with the gathering of data from all stages of exploration, development and production. Technological advances have made it possible to digitally monitor many more aspects of these processes than was possible a decade ago. But data is nothing more than ones and zeroes until it is turned into the kind of knowledge that can be used to exert real-time control over BP's operations. Even then, there remain some big steps to take: automating the processes that govern those operations, and integrating BP's operations and supply chain world-wide.

In order to build this kind of capability across the remarkable range of offshore oilfields in numerous locations, BP had to construct a cutting-edge communications network which uses more than 2,000 »

kilometres (1,240 miles) of fibre optic cable to link offshore fields to BP's 35 'advanced collaborative environment' (ACE) centres around the world. In these ACEs, BP engineers and scientists study information from platforms as it's gathered, and advise offshore operators, no matter where they are and whatever the weather conditions may be.

Speaking at this year's Intelligent Energy Conference, BP's chief scientist, Dr Ellen Williams, said BP has "opened up a veritable orchard of low-hanging fruit" over the past decade – work that can now be done in a reasonably short timeframe in areas such as real-time well surveillance, supporting reservoir management, integrity monitoring and evaluation, and standardising best practice.

She said that most of the progress had come from digitising measurements and speeding up analysis. "Moving forward, we have a wealth of choices. Simply prioritising and integrating the low-hanging fruit we now see from digitising operations might lead us within five to 10 years to fully integrated strategic systems."

BP now integrates cutting-edge technology into the design of its new major projects right from the outset. The first of these 'digital oilfields' is expected to start being used in production this year in the Norwegian North Sea, at Valhall – which has been producing for 30 years – and BP's new field, Skarv.

Managing operational risk with digital radiography

The integrity of subsea pipelines is traditionally inspected by smart 'pigs' – pipeline inspection gauges – devices that travel along the inside of pipes measuring the thickness of the pipe wall with sensors. It's a tried and tested method that does the job effectively.

But pigs need sites where they can be both launched and received, which rules them out in less accessible locations. For example, only around 30% of the industry's 78,000-kilometre (48,470-mile) offshore subsea pipe network can be inspected this way. The other downside of using pigs is that they must enter the hydrocarbon fluid stream and there are risks associated with this. The inside of the pipe must be scrupulously cleaned before it's inspected too, using another pig, which can add risk, time and complexity.

But now, BP is working with partners to take a proven, land-based inspection technology, radiography, into the hostile subsea environment. Originally developed for the medical world, digital plates are now replacing photographic film in capturing images. BP ran its first pilot last year at Madoes in the ETAP field in the North Sea. First, the plates had to be 'marinised' – made suitable for high-pressure subsea conditions – then, at a depth of 90 metres (300 feet), divers manually rotated a low-energy gamma ray projector and detector around a pipe to gather digital images, which were then transmitted to the surface in real time to be analysed and interpreted.

Following that test, the technology was taken to depths human divers cannot reach and a remotely operated vehicle (ROV) tested the technology at a depth of 460 metres (1,500 feet) in a pilot in October 2011 at the Pompano field in the Gulf of Mexico.

Practical application: BP's Valhall field, Norway, has been producing for 30 years but will start operating as a 'digital oilfield' this year, using an array of real-time technologies.

The next step was to figure out how to go far beyond the 610 metre (2,000 feet) depth limit associated with existing technology. BP has pipes as deep as 2,285 metres (7,500 feet), so it's now working with partners to produce a version that will work down to 2,440 metres (8,000 feet).

Jon Rogers, BP director, corrosion and chemistry, says: "We have been trialling the deepwater system in the Gulf of Mexico in the fourth quarter of 2012. Following the trials, we are aiming to deploy this new technology wherever we have subsea pipelines. The main benefit it will bring is enabling us to inspect the deepwater subsea lines that we can't currently reach. But it also gives us the ability to inspect lines more quickly and more effectively without breaking containment. It's a significant step forward in our efforts to manage and reduce integrity risks in our subsea pipelines."

Optimising production with slug controller

Sophisticated digital optimisation technology has been used to overcome a common industry problem: unstable flow in pipelines and risers, known as slugging.

Slugging can cause a multitude of problems, from the sand face to export pipelines. The separation of solids, liquids and gases can be affected by variations in the flow rate, while the surging of gas can increase the risk of a platform trip, where an entire platform is temporarily shut down as a safety measure while pressure is stabilised. At the sand face, pressure fluctuations associated with slugging will exert additional stresses on equipment. Sand production is often higher and the risk of a completion failure is significantly increased.

In the past, the only way to address this problem was for engineers to manually restrict flow by closing choke valves on the surface. Now, taking the work into the digital world, BP's slug controller uses real-time measurements and complex algorithms to identify slugs as they form, making automatic adjustments to the choke to stabilise the flow without stopping production.

The slug controller has added around 5,000 barrels a day net of extra production across BP's biggest deepwater operating regions: the North Sea, Gulf of Mexico and Angola.

"Slug controller is a great example of a process that we've managed to automate," says Roberts. "Operators used to juggle valves to try and stabilise that flow. By automating it, we've taken the process to a level that an operator simply couldn't achieve."

Improving efficiency with data-driven virtual flow meters

Monitoring how oil and gas wells are behaving and adjusting production equipment to optimise the flow is central to the energy business – and it's a process that has been transformed by real-time digital technology.

At the heart of BP's digital well surveillance system is a virtual flow metering (VFM) module that uses data gathered by well monitoring sensors to estimate production rates of individual wells without the need for physical flow meters.

The VFM system works by feeding sensor data into a mathematical model based on what engineers know about the physics associated with the changes in pressures and temperatures at various points of the journey from the reservoir, into the well, up the pipework of the well and then through the production choke. Every month or so, the VFM's predictions are adjusted according to actual measurements taken using physical flow meters.

More than 300 BP wells across four continents currently use this VFM system. Having access to accurate well production rate estimates close to real time improves engineers' understanding of well performance, making it possible to optimise production across fields while keeping operations within the equipment's safe limits.

The VFM network is part of what BP calls its Integrated Surveillance Information System (ISIS), which has been at the core of the company's *Field of the Future*® technology flagship programme for more than a decade.

BP is working on evermore-sophisticated virtual flow meter systems, increasingly based on mathematical calculations rather than physical measurements.

It's also important to gauge flow rates in order to control vibration caused by the flow of liquids through subsea pipeline networks such as the one at BP's Thunder Horse field in the Gulf of Mexico. This system comprises 10 subsea producing wells spread over 116,550 square kilometres (45,000 square miles), all linked by subsea flow-lines.

To minimise vibration and maximise the life of the equipment, engineers set maximum safe target flow rates. But because of inaccuracies built into the way physical measurements are taken, a safety margin of 15% must be built in – and that adds up to a lot of deferred production.

Thanks to BP's use of state-of-the-art monitoring technology and the deployment of ISIS and VFM, Thunder Horse engineers are able to calculate individual well rates with great accuracy in real time and adjust flows much more precisely, which translates to a benefit of 10,000 barrels a day. ■

"[Radiography] gives us the ability to inspect lines more quickly and effectively without breaking containment. It's a significant step forward in our efforts to manage and reduce integrity risks in our subsea pipelines."

Jon Rogers

Report> Nic Welsh
Photography> Getty/Stuart Conway/Aaron Tait/Graham Trott/
Richard Davies/Joshua Drake/Corbis

BP at the Games:

a team effort

At the height of BP's support for the London 2012 Olympic and Paralympic Games, more than 1,000 people across multiple teams and organisations pulled together to help deliver the company's commitments as an Official Partner. A few of that team share their memories of the experience with *BP Magazine*.

Memorable experiences: (opposite clockwise from top) one of the six international projects that BP Target Neutral supports as part of its London 2012 commitments. It is located in China and helps generate electricity from biomass made from matter such as rice husk; throughout the Games, BP provided fuel for the official fleet, which was directed to a number of priority sites within the Greater London area; Great Britain's Richard Whitehead celebrates after his win in the men's 200m – T42; and inside BP's Fuelling the Future showcase at the Olympic Park. Below: Paralympians soak up the atmosphere at the Paralymic Games Closing Ceremony on 9 September 2012.

London 2012
Olympic & Paralympic Games

In July 2008, Mike Sharrock and I stood and watched archers, gymnasts, fencers and judo experts demonstrate their skills underneath the British Museum's famous glass atrium canopy. The display was designed to highlight the strong link between sport and culture and to mark BP's announcement that it was to be an Official Partner of the London 2012 Olympic and Paralympic Games. I asked Sharrock, then soon to become BP's London 2012 partnership director, what success for BP would look like to him once the Games officially closed. He replied: "We want to do the right things, make people feel proud, and look back in four years' time and see that we have produced something truly memorable."

Four years on, Sharrock looks back: "We always said, right from the beginning, that we would do a small number of activities and that we would do them as well as we could. I think BP has delivered more than we could have expected and the feedback from people across the company and from our business partners has been overwhelming."

BP's role in the Games might have focused on a small number of activities but their range was huge. At the very start, the company made two operational commitments to the London Organising Committee of the Olympic and Paralympic Games (LOCOG): to supply fuel for the BMW fleet and provide liquefied petroleum gas (LPG) for catering services at 26 Olympic and Paralympic venues. Both were achieved safely despite some challenging circumstances – fuel supplies in the UK came under pressure early in 2012 with uncertainty around the future of Coryton refinery, while BP announced earlier this year that it was divesting its LPG business.

Neale Smither, manager of the UK sales and marketing fuels value chain, is full of praise for his teams: "The fuels team built a very strong relationship with LOCOG and did a fantastic job of delivering fuels faultlessly with zero incidents, while the LPG team delivered an absolutely amazing performance during an uncertain period for them. Distribution was carried out at night to 26 different venues, again without incident. Both teams were a real credit to BP throughout the Games."

Another key aspect of BP's commitment was its support of more than 60 Olympic and Paralympic athletes from nine different countries. Part of that support included hosting several of the athletes' families throughout the Games and, as a consequence, the London 2012 team caught a glimpse of what it's like to be related to a world-class sportsperson as the families watched their loved ones compete for the biggest prizes of their lives. "It generally followed the same pattern," Jake Jones, BP's athlete engagement manager says. "For about half an hour before a race, they would be unable to speak, followed by an outpouring of emotion. Sharing these moments was very special."

BP's support for athletes was split equally between Olympians and Paralympians. Sharrock says: "We made a real point right from the beginning that we would have absolute parity across the Olympics and Paralympics, both in our athlete support and in our advertising. It just seemed like a very natural thing for us to do."

The effort made by LOCOG and all the partners to raise the Paralympic profile paid off, with the majority of the 2.5 million available tickets sold. It's also led to the development of some strong partnerships between BP and several national Paralympic Associations. In the US, particularly, the BP team has worked hard to support a nationwide Paralympic Sports Club initiative, as well as the Warrior Games, in which the competitors are injured service members and veterans. "Seeing the way that the Paralympics touched so many of our people, and the multiple and effective actions BP took to contribute to this success has been a real highlight," says Steve Williams, BP's head of US Olympic and Paralympic programmes.

BP's physical presence throughout London 2012 was demonstrated through »

Athlete support: (clockwise from top left) Azerbaijan's Afag Sultanova poses with her gold medal following her win in the women's -57kg judo contest. Afag was one of more than 60 athletes that BP supported in the run-up to and during the Games; a sitting volleyball competition during the 2012 Warrior Games in the US. BP is a supporter of the Games; and members of Team GB wave to crowds of fans in London during the Heroes' Parade on 10 September. A number of BP's tanker drivers drove the floats.

"We made a real point right from the beginning that we would have absolute parity across the Olympics and Paralympics, both in our athlete support and in our advertising. It just seemed like a very natural thing for us to do."

Mike Sharrock

Diverse activities: (from left) BP's cellulosic ethanol demonstration plant, at Jennings, Louisiana, US. Biofuels produced at Jennings were used to fuel a number of London 2012 vehicles; BP employee Julie Amos (left) and Hally Nguyen participated in the BP-supported Young Leaders Programme which was designed to inspire young people to engage with the Games and develop their leadership skills; Russian gymnast Olga Korbut poses for the cameras at the Royal Opera House. Olga was one of 16 inspiring athletes featured in *The Olympic Journey: The Story of the Games* exhibition; a Clarity employee at work. The soap and toiletries manufacturer provides opportunities for blind and disabled people and is one of a number of organisations supported by the 'arc' social enterprise programme.

a number of showcases, including two at the Olympic Park itself, attracting 150,000 visitors during Games-time. The Fuelling the Future 'pop-up' pavilion housed a 360° film featuring a number of BP's athlete ambassadors who introduced some of its key business activities. Meanwhile, next to the Aquatics Centre, the BP Walk in the Olympic Park 'periscope' allowed visitors to have their photograph taken in front of the Olympic Stadium. In exchange, visitors signed up to have the carbon emissions associated with their travel to the Games offset through BP's Target Neutral programme. "The Target Neutral team succeeded in signing up more than half a million people to offset their journeys," says Andrea Abrahams, global director of BP Target Neutral. "That's an incredible performance and we now have many thousands of people who are part of a network aimed at encouraging greater sustainability."

As a Premier Partner of the Cultural Olympiad and the London 2012 Festival, BP called on its long-standing relationships with four key arts and cultural partners – the British Museum, Tate Britain, the National Portrait Gallery and the Royal Opera House (ROH) – as well as a new partnership with the Royal Shakespeare Company, to create a series of world-class projects in the run-up to the Games and during the Festival in 2012.

"At the peak of our support during the Games, the BP London 2012 team included more than 1,000 people, comprising people from across the company and others from multiple agencies. It was a wonderful example of working as one team."

Mike Sharrock

"Each of those partners wanted to do something really special," says Des Violaris, BP director for arts and culture, "and BP was able to help them create and deliver programmes and activities that might not have happened otherwise. It allowed us to extend our partnerships beyond what we would do in a 'normal' year."

Violaris is particularly proud of BP's relationship with the ROH, which she confesses BP 'moved into' for the two weeks of the Olympic Games, following an intensive 36 hours set-up period. As well as hosting BP guests in its hospitality lounge, the venue was also home to BP's *Technology Experience* and *The Olympic Journey: The Story of the Games* – an exhibition telling the story of the Olympics from ancient Greece to the modern day. It featured all the Summer Olympic Torches since 1936, all the medals since 1896 and a special area highlighting the achievements of 16 of the most inspiring athletes of the modern era. The exhibition, a collaboration between BP, the ROH and the Olympic Museum in Lausanne, Switzerland, was free to the public and welcomed 40,000 visitors during the Olympic Games.

Violaris says: "I think what marked our experience of the Royal Opera House was the generosity of Tony Hall [then ROH chief executive] and his whole team. They welcomed BP into their home for two weeks and we are immensely grateful. I believe this shared experience will take all of our relationships on to an even better, deeper level."

At the heart of BP's London 2012 activities has been a desire to create a sense of legacy. Like LOCOG, the company was determined to develop programmes that would last well beyond the glow of the Games. It's this commitment that led to an impressive list of achievements: from a world record for the number of offsets to a single event and the trial of three new biofuels in a number of vehicles in the official Games fleet, to 70 BP graduate recruits having the opportunity to spend their first three months in LOCOG, helping to deliver the Games and the successful graduation of around 80 young people from the BP-supported Young Leaders Programme – designed to help teenagers develop their interpersonal and leadership skills through access to BP mentors. An employment legacy was also developed, with new jobs created through the BP-supported 'arc' social enterprise programme with Business in the Community.

"Many people across the company have worked very hard to ensure that everything created in the past four years delivers a lasting legacy," says Sharrock, "as well as enduring value for BP."

While the focus now turns to Brazil and Rio 2016, BP's work isn't over just yet. Many of its links with National Olympic and Paralympic Committees will continue for a number of years and multiple teams are now busy studying the lessons learned from London 2012 to ensure the legacy inside BP is just as enduring. "Whatever the future is going to be, I think for now, we can look back and be pleased with what we have done," Sharrock says.

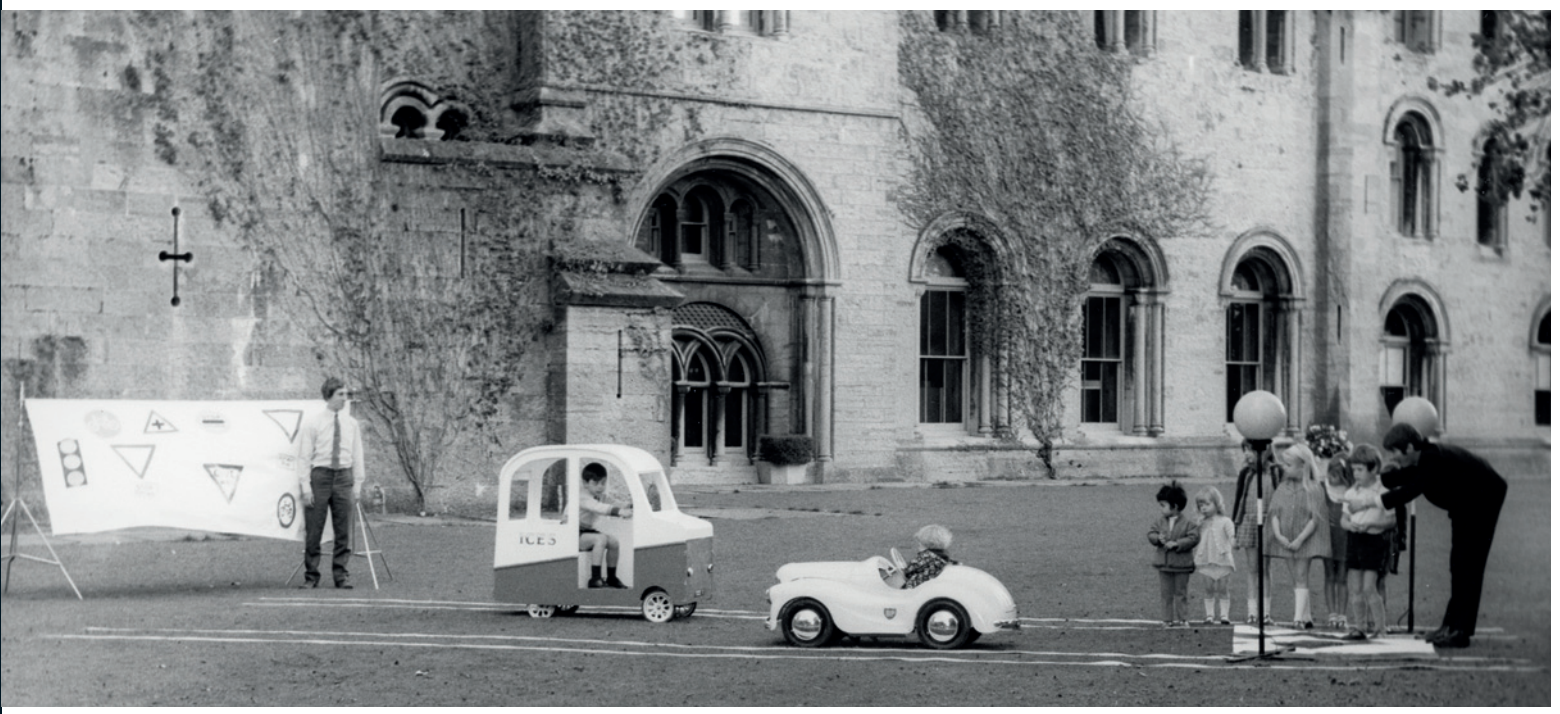
It all sounds so simple in hindsight, but the task of scaling up to an event of this size was immense and Sharrock is enormously proud of what was achieved. He says: "What BP ended up delivering was much bigger than anticipated. To deliver all of BP's activities from a very small base, to deliver multiple projects in a very short time frame and to do all that with safety as the absolute first priority was really an exciting challenge for all involved.

"At the peak of our support during the Games, the BP London 2012 team included more than 1,000 people, comprising people from across the company and others from multiple agencies. It was a wonderful example of working as one team. As well as delivering on our commitments, we wanted London 2012 to be a memorable experience for everyone working on the project; one that would require an intense effort from many over a prolonged period, but one that had to be a positive experience. To hear many of those people say it has been a career highlight is very special. It's been a real privilege to be part of it." ■

Photography> BP Archive

ON THE ROAD AGAIN

Over the years, BP has been involved in a variety of road safety initiatives, many of them aimed at children. One of the most successful was Mr Beep – the talking car. Over the next few pages, *BP Magazine* tracks some of his travels and looks at a small selection of other road safety programmes in which the company has been involved.



Opposite: Mr Beep – the talking car. Mr Beep first appeared in Canadian advertising in the late 1950s, and small models were sold through service stations. In 1959, this full-size version was constructed and travelled throughout Ontario, giving traffic safety lectures to schoolchildren. Mr Beep's voice came from three speakers concealed in the bodywork and a shortwave transmitter that allowed a remote operator to project the voice from a wireless station. A microphone in the hood transmitted the children's questions back to the operator. Mr Beep eventually travelled farther afield and is photographed here at a BP service station in south England in April 1962. **Above:** young children take part in a road safety briefing at Penrhyn Castle, Wales, in December 1970. **Below:** after England, Mr Beep headed for Africa, visiting a number of countries. Here, his arrival is celebrated in Ghana with an unveiling ceremony at Kumasi Prince of Wales Park, June 1962.

Top: Mr Beep on show at the Central Canada Exhibition, Ottawa. The car was made from fibre-glass and steel, had a six-cylinder engine and could seat three people. **Above:** Mr R O Beaudoin, development assistant for BP Canada, is pictured with Mr E A Brown, the man who built Mr Beep. **Right:** schoolchildren from Colham Manor school, south England, take part in a BP Oil road safety programme, June 1994.

Left: children take part in activities to mark the launch of the 'Living with Traffic Go International' programme, October 1992. Princess Michael of Kent and BP board member Russell Seal were also present. **Below:** a road safety show at Redlands Primary School, south England, June 1994. **Bottom:** the BP road safety team at work in 1973. The interactive programme provided children with a variety of tips for road safety awareness, including basic road signs.

Photography> Richard Davies

Clear enterprise

Photographer Richard Davies captured this image at Clarity, a manufacturing business that provides employment for blind and disabled people. Clarity is participating in arc, a programme linking business to social enterprises with the ultimate goal of creating 1,000 new jobs. BP is a founding partner. The programme launched in East London in September 2011 and expanded to West London in December 2012 due to its success. *BP Magazine* will feature a full report on arc in Issue 2 2013.

BP in India... There is energy in this partnership.

BP is a leading international energy company having a 100 year relationship with India. This has been steadily built over the years through our presence in oil, natural gas, petrochemicals and our cutting edge lubricants, Castrol. Now there is new energy in this partnership. We have invested over ₹40,000 crores in India making us the largest international energy company here. We continue to develop local talent, deploy advanced technologies and work towards securing a better energy future for the country. BP remains deeply committed to India. Find out more at bp.com

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