Shenzi

After six years, still the top-performing deepwater development in the Gulf of Mexico
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A story years in the making

How do you know when you’ve built a successful deepwater field? Is it the day you receive first oil? Is it the month you reach peak production? We say it takes time—years in fact—to know if all your decisions were right.

In 2015, BHP Billiton’s Shenzi field, a world-class deepwater oil and gas development in the U.S. Gulf of Mexico, entered its sixth year of production. After first oil on March 23 of 2009, Shenzi—named after a mythical flying dragon—took just three months to reach 130,000 barrels of oil per day. A month later, production peaked at 149,500 barrels. In 2015, Shenzi is still delivering some 95,000 barrels of oil per day, just under its nameplate capacity of 100,000 barrels of oil per day. Since startup, the facility has been up and running more than 95 percent of the time. No other deepwater platform in the U.S. Gulf of Mexico has done as well.

This is the story of Shenzi’s success.
A Significant Find

The discovery of one of the Gulf’s most challenging plays

Nearly a quarter of all the oil produced in the U.S. Gulf of Mexico comes from a relatively small region geologists call the Western Atwater Fold Belt. Since 1995, a series of ultra-deepwater discoveries in the Western Atwater Fold Belt area have identified a potential resource of more than two billion barrels of oil. Among the six fields now producing it, Shenzi is the most successful.

The biggest challenge, aside from the extreme water depths, is that much of the rock in the Western Atwater Fold Belt lies below a thick sheet of salt that hides potential reservoirs from seismic signals. Even so, by using the most advanced seismic imaging and modeling technology, explorers in recent years have been able to find oil about 60 percent of the time.

**Discovery of the Shenzi Field**

In 1995, BHP Billiton bought into a share of leases in Green Canyon Blocks 609, 610, 653 and 654, which lie along the same geologic trend as Mad Dog, Atlantis and Neptune. Subsequently, BHP Billiton became the operator of Shenzi and Neptune, while BP developed Mad Dog and Atlantis.

Under a long-term contract to BHP Billiton, Transocean’s drill ship C.R. Luigs spudded the first exploration well in Green Canyon Block 654 in the fall of 2002. Working at water depths of 1,341 meters (4,400 feet), the Shenzi-1 exploration well reached a measured depth of 8,109 meters (26,607 feet). By mid-November, the company announced that Shenzi-1 had encountered 142 meters (465 feet) of hydrocarbons and 43 meters (140 feet) of net pay.
Explorers moved the C.R. Luigs about 3 kilometers southwest of the discovery site to begin drilling an appraisal well in September 2003. What they found in the lower Miocene sandstone was even larger than the discovery at Shenzi-1, some 381 meters (1,250 feet) of gross hydrocarbons and 152 meters (500 feet) of net oil. Shenzi-3, drilled in 2004, further delineated the southern portion of the field.

As drillers gained more experience, development wells in the Shenzi field began setting efficiency records. In May, 2007, the C.R. Luigs averaged just 1.54 days per 305 meters (1,000 feet) of new hole, reaching a total depth of some 8,186 meters (26,857 feet) in only 35 days. That matched a milestone set the previous month by Transocean’s semi-submersible Development Driller I on BHP Billiton’s adjacent Neptune field. In early 2015, drillers in the Shenzi field continue to deliver top-quartile industry performance.

“Deepwater wells typically range from 35 percent to 60 percent of the development cost,” says Steve Pastor, asset president, Conventional. “We have demonstrated over the course of the last ten years an ability to drill deepwater wells as much as 50 percent faster than our competitors drilling in the Gulf of Mexico.”

“Conditions are never the same from one field to the next,” Pastor says, “but when you stack our performance against other deepwater operators, we have demonstrated an ability to consistently deliver at lower cost and faster cycle time, and to deliver more value from similar fields. And that is true everywhere we operate worldwide.”

Steve Pastor is the asset president for Conventional at BHP Billiton Petroleum.
A Seismic Breakthrough

To make Shenzi happen, a breakthrough in subsalt seismic imaging was essential. A key to Shenzi’s success was a new technology called Rich Azimuth Seismic that BHP Billiton developed. In the image on the right made in late 2014, the salt deposits are strikingly clear compared to an image of the same deposits from a decade earlier. Welcome to the high-tech world of oil and gas.
Evaluating the Potential

“To truly know what you’ve got, you must first understand the basin.”

In the U.S. Gulf of Mexico, Southeastern Australia and Western Australia, BHP Billiton’s explorers and geoscientists are creating a seamless story of the geology, from continent-sized tectonic plates down to microscopic pores in the rocks. They build on their knowledge of these heartland basins every day. Beyond that, their Geoscience team is evaluating data from a 10,000 sq. km. (3,860 sq. mi.) seismic survey taken off the coast of South Africa in 2013, and a recently completed program off Trinidad and Tobago, which, at more than 21,200 sq. km. (8,185 sq. mi.), is the largest seismic survey ever made by an independent oil company.

BHP Billiton studies very large areas because it is important to know not only how potential reservoirs look now, but how the basins formed and changed over time. It’s more than curiosity. In challenging deepwater developments such as Shenzi, a thorough knowledge of the basin gives the company the confidence and precision it needs to develop resources in the most efficient way.

All Eyes on Shenzi

The next time you’re in a commercial airliner at cruising altitude over a large city, look down and pick out an average office building. Imagine that you are on a deepwater drilling vessel, floating in 1,200 meters (4,000 feet) of water, and that the building is the reservoir you’re trying to reach. Between you and the target zone is more than 10 kilometers (6.2 miles) of seawater, ductile salt and solid rock.

“The imaging techniques we use on Shenzi today are at the forefront of the industry worldwide,” says Niall McCormack, BHP Billiton Petroleum’s vice president of Exploration.

Since the mid-1990s, the complex geology of this region has been an industry development ground for new seismic technology. The biggest roadblock for explorers remains the complexity of the thick layer of salt that obscures potential reservoirs from seismic signals.

“The first images of Shenzi looked like a child’s drawing of a tree,” McCormack says. “You could see some geology coming up, then it was just a cloud sitting on top. Mapping that and understanding what we were seeing was incredibly difficult. It involved a very strong integration of geology and geophysics to understand what was really an image of the geology, and what was just artifact.”

For the Shenzi development project to succeed, an improvement in subsalt seismic imaging was essential. One key to Shenzi’s success was a new technology, Rich Azimuth Seismic, which was developed...
by BHP Billiton’s Seismic Imaging and Development teams. Rich Azimuth Seismic is now the new standard for studying subsalt reservoirs worldwide.

“We don’t take shortcuts,” McCormack adds. “We need to understand the system from the scale of the geological plate to the pores in the rock. We honor the goal of being sustainable and performing with integrity, and at the same time, giving ourselves the best chance of finding oil.”

**Fit for Purpose**

“We’ve been accused of overanalyzing,” says Bob Comstock, project director for the Shenzi development. “But we think the value we receive from properly appraising a field and understanding everything from rock mechanics through the reservoir is well worth the effort.”

There are examples of companies that have suggested that they could sanction projects based on the results from a single well, but to proceed with a multi-billion dollar project on such slim data—however promising it looks—is risky. The odds are great that you’ll end up with a facility that is too large, too small, or otherwise unfit to develop the resource efficiently.

“I’ve been involved with a number of developments in my career,” Comstock says. “As we move along from exploration to development, we begin conceptual studies to determine the best type of facility and infrastructure for each field. We look at different development scenarios and run the economics. Based on our experience, we determine how much we can afford to spend on a particular type of field development. I believe it’s something we do better than most other companies.”

BHP Billiton excels at producing the right design for its facilities and building them at the right cost. Aside from the initial economics, a fit-for-purpose infrastructure will last longer, have lower maintenance costs and achieve greater up-time than a development that is not the optimal design. “Even in the most challenging reservoirs,” Comstock adds, “we have a reputation of being able to return value to our stakeholders.”

Bob Comstock led the Shenzi development team.
Developing the Field

How to create early returns and lasting value

Based on strong results from the first three Shenzi wells, Bob Comstock’s team became responsible for building the offshore infrastructure needed to develop and support the field. The idea was simple enough: focus first on safety, then generate income as quickly as possible.
The Critical Path
With the goal being to maximize value, the team analyzed the project in terms of a critical path. Which items absolutely had to be in place before Shenzi saw its first barrel, which items could wait, and what would it cost to do it? All the numbers went into the economic model.

“We analyzed every step,” Comstock recalls. “Each time we solved one piece of the puzzle, we shortened the time to first oil. Then we looked at the next critical item, and then the next, and so on down the line.”

As the development team shortened the critical path, it added value to the venture and made money for the joint venture partners. The government benefited as well, because the early startup meant Shenzi began paying taxes and royalties sooner.

“As we understood exactly where we were, that critical path became a lot steeper,” Comstock adds. “We looked at everything, and it paid off. Shenzi was sanctioned for $4.6 billion, but we’d spent about $2.8 billion of that by the time we had first oil. By holding our cost down to begin with, and generating income sooner, we created real value.”

A Lean, Integrated Team
Comstock kept the Shenzi group relatively small, yet well informed. While many companies talk about “integrated” teams, the members seldom see each other except for scheduled meetings. Almost everyone involved with Shenzi was relocated on one floor of the BHP Billiton building in Houston. Team members talked every day, and over the next 36 months, they came to know each other very well.

“There were a dozen babies born and half a dozen weddings,” Comstock says. “We celebrated them all. We became like a family. You can’t have that type of atmosphere if people don’t know who you are.”

Eyes on Mexico’s side of the Gulf of Mexico
BHP Billiton is keen to translate its project and operational expertise in the Gulf of Mexico into partnership opportunities as Mexico opens up its energy sector to international oil companies.

“With the financial strength of a supermajor and nimbleness of an independent, we believe BHP Billiton is the ideal partner,” says Tim Cutt, president of the company’s global Petroleum business. “We can offer absolute focus. Plus, we bring to the table our deep knowledge of the overall geologic basin. That alone could lead to tremendous investment and value creation. At the end of the day – it’s all about the rocks!”

In preparation for Mexico’s historic lease sales in 2015, BHP Billiton established an office in Mexico City the year before, headed by Director General Tim Callahan. “We see great potential here,” says Callahan from Mexico City. “Our aspiration is to take our experience in U.S. deepwater developments and replicate that success on Mexico’s side of the border.

“We applaud Mexico for the openness and transparency it has built into its new system. It is an exciting time to be working in Mexico at this historic juncture in the country’s history!”
After its fabrication in a South Korea shipyard, Shenzi’s hull was shipped half way around the world, and now keeps Shenzi afloat above 1,341 meters (4,400 feet) of water.
What does “nameplate” capacity really mean?

For the record, Shenzi was built with a nameplate capacity of 100,000 barrels of oil and 50 million cubic feet of natural gas per day. Does that mean that producing more oil and gas from the facility is dangerous or unlikely? Not at all.

Shenzi’s peak capacity is 150,000 barrels of fluids per day. That is the physical limit of how much oil, gas and water can pass through its vessels, manifolds and pipes in 24 hours. The challenge for producers is not the volume of fluids, but how much of the fluid is liquid hydrocarbons. New fields often show high oil-to-water ratios early on, but that typically drops off as wells begin yielding more water. The challenge is to keep producing oil and gas at the facility’s full nameplate capacity for as long as you can. That is what Shenzi’s operators have managed to do for six years.

Comstock encouraged regular feedback and a free flow of information from all sides. Reservoir engineers talked to facilities engineers, economists, safety professionals and procurement specialists. Everyone was engaged. It also helped to keep the team relatively small, and supervisors themselves did much of the work.

The Shenzi team included people from some of the project’s major contractors and its joint venture partners. “Field trips” to vendors such as Dril-Quip or Cameron to see the subsea wellheads or trees, or to the Kiewit’s Ingleside yard, where the Shenzi topsides were being built, allowed the non-technical staff to see some of the critical hardware.

Managing Well Quality and Cost

Designing the Shenzi wells for long-term production was especially challenging for the drilling team. Since the target zone was located below thousands of meters of salt, there was a danger that salt would squeeze into the wellbore, collapsing the production casing.
Another problem was annular pressure buildup (APB). During well production, the resulting heat-induced rise in pressure threatened to exceed the design rating of the casing. There were also wellbore stability issues if the wells were not drilled perpendicular to the angle in which the beds dipped.

“These were serious problems,” says Derek Cardno, Drilling and Completions vice president. “We had to locate the drill centers in exactly the right place to make the wells drillable. We also had to use relatively unproven solutions to mitigate the salt creep and APB risks.”

The APB solution was to use vacuum-insulated tubing, which effectively prevents the heat from being conducted into the outer annuli. Not only were there drilling well-construction challenges, but every completion component was to be used at loads at, or exceeding, existing design specifications. Detailed design reviews, qualification testing and design modifications were necessary for items such as production packers. There were also operational challenges.

“The wells were all around 7,600 vertical meters (25,000 vertical feet),” Cardno explains. “That means the string loads—the weight of all the pipe (drill pipe and casing) suspended from the derrick—were very high. We were dealing with hook loads that were close to the capability of the rig, and as high as any in the industry at the time.”

Solving such problems made Shenzi the highlight of many professional careers. The drilling and completions team focused hard on not only the design challenges but also on flawless execution.

Derek Cardno, Drilling and Completions vice president.

Rig crews and service companies were included in planning and operational reviews — with a particular focus on simplicity and continuous improvement. The end result was industry leading drilling and completions performance. Significantly, to date, there have been zero well failures after handover to production.

“What made that project special is the way we characterized the reservoir and recognized what we knew and what we did not know,” says Doug Peck, Reservoir Engineering senior manager. “We came to understand how each unknown could affect the project in various scenarios. We designed the facility and the project with the flexibility to handle all those variables.”

One example was the provision to drill producer and injector wells where needed. We needed water injection in a shallower horizon on production,” Peck says. “With the flexibility designed into the subsea system, we were able to place the injector where needed. We added a lot of value by being able to drill that injector when and where it was needed most.
Keeping the drill bit turning

The C.R. Luigs spudded the first exploration well for Shenzi in 2002, and has done the lion’s share of drilling for the Shenzi and Neptune development since then.
The Reservoirs and Wells

World-class delivery with a lean, efficient team

BHP Billiton typically executes most of its subsea projects with a core team of 15 to 20 staff or direct-hire contractors. The super majors may have twice that many. That drives up cost, but adds very little to the outcome. One thing that made the Shenzi project special was the effort that the team made to understand such a challenging reservoir and plan for the uncertainties.

Managing to Stay Trim

“We believe in building things that are safe and fit for purpose,” says A. J. Terrell, senior manager for brownfield projects. We’re smaller and leaner than some companies, but also more efficient. And when we save money on our projects, we’re adding real value that our business partners can see.”

It’s a difference in management style.

“A manager’s job is to build the environment and build the team that can execute the work; to assemble the right people and tools to get the job done,” Terrell says. “Beyond that, the manager’s job is to allow people to do what they’re trained and capable of doing, rather than micro-managing the team.”

Two examples show the effectiveness of BHP Billiton’s approach. The first one, Integrated Field Management®, addressed the challenge of increasing production from Shenzi’s wells without capital expense. The second example, adding water injection to the Shenzi field, illustrates how a small and efficient team was able to save time and money on a large multi-year project.

Integrated Field Management®

The Shenzi TLP has 17 producing wells, each capable of flowing at different pressures. The wells with the higher pressures can limit production from the lower-pressure wells into the common gathering system. To improve the efficiency of the gathering system, Shenzi’s production engineers identified and implemented a piece of software called Integrated Field Management®, or IFM.

“The IFM software allows the engineers to model the effect of swapping wells into different gathering system flowlines and adjusting gas-lift rates for multiple scenarios at a time,” says Graham Salmond, former Operations Manager. “Prior to implementing the software, modeling of the system was difficult...
and time consuming. Now we have the confidence that production is optimized every day.”

**Water Injection**

At some point in the life of an oil reservoir, operators may choose to inject huge amounts of water to push oil through the reservoir toward the producing wells. The practice is so widespread that a field’s original development plan often includes the necessary equipment on the production platform, even if it is not yet needed.

That was the case for Shenzi, when some members of the original development team argued for installing a water injection system right away. Others advised against it.

Besides the water injection wells themselves, equipment on the production platform includes all of the kit required to collect the sea water used for injection, remove the impurities, then treat it. That includes coarse filtration, ultrafiltration, sulfate removal membranes, and deoxygenation prior to injection into subsea wells.

“On Shenzi, we made the decision not to include water injection up front,” says Bob Comstock, Shenzi project director. “We took a lot of flak for that, but the fact was, we didn’t yet understand the reservoir. We knew we might eventually need water injection, but we didn’t know how much.”

So the project team built the TLP knowing that the capability for water injection could be added later on. The argument against waiting was that it would cost more, and that the production platform would have to be shut down for a while to install the equipment.

“We provided for the weight and space when we designed the TLP,” says Richard Jacobs, leader of the water injection project team. “Later, we did add water injection, but it was not as time consuming or expensive as critics thought it might be.”

There were two main parts of the work: Installing the subsea kit and adding equipment to the Shenzi platform.
“The major challenge was that we had a facility that was producing 100,000 barrels of oil per day, and we needed to make major modifications,” Jacobs says. “It was a huge project that demanded significant collaboration between the operations and project teams to do the work safely, while having a minimum impact on production. We drilled the wells in 2010 and 2011. The topsides facilities were installed between June 2011 and February 2012. Water injection began in May 2012 and has continued since then.”

Lost production time was a big concern. The original schedule called for the work to be done with five shutdowns for a total of 60 days. At the end, however, all of the work was completed with two shutdowns and a total of only 10 days dedicated to water injection activities. And even though the schedule was intense, no one got hurt on the job.

In February 2012, Shenzi had three new wells and a water injection system that could deliver 125,000 barrels per day. By then, the field had been producing long enough that the field’s reservoir engineers knew how much water injection was needed.

“The system was fit for purpose and the cost was right,” Jacobs adds. “The technology had even improved since 2009, so by waiting, the equipment we put in was better than what we would have gotten earlier. We’d also learned more about the reservoir from our first few production wells. Based on that, we made modifications to lower the cost of drilling the water injection wells, and we were better able to place them.”

Water flooding works better in some fields than others. Its success depends on many factors, such as the type of rock, orientation of the natural fractures, and the amount of existing water in the reservoir.

“Water injection has not been without its challenges in the Gulf of Mexico, and Shenzi is no exception,” says Andrea Stewart, senior manager, Subsurface. “But in the M9-Upper reservoir, it has been very successful. We just drilled a second producer into that reservoir and are evaluating an opportunity for another injector. We wholly attribute the 12,000 barrels per day of production from our B201 well to water injection success. For every barrel of water we put in, we’re getting close to one barrel of oil out. It’s a textbook waterflood.”

The integrated team continues to focus on understanding and improving water injection performance in the rest of the Shenzi field.
A Wider Technical Base

BHP Billiton’s global Petroleum organization is unique among its competitors, for it is one of four key businesses in the world’s largest minerals mining company. So, as part of BHP Billiton, Petroleum’s geoscientists and engineers have direct access to experts in related scientific fields other than oil and gas. The technical exchange flows both ways. It is a resource that few other companies have.
A Safe Place to Work

Sustainable ways to reduce exposure in high-risk jobs

Shenzi and Neptune are both recognized for their “Best in Class” health, safety and environmental performance. In 2014, BHP Billiton’s Neptune TLP reached a safety milestone by achieving five years without a recordable injury and seven years without a lost-time incident. The crews offshore and the ones onshore who support them are among the safest in the industry.

Managing Material Risks

One of the key differences among companies that operate in high-risk industries is the way they manage situations in which lives, facilities and even the company itself could be threatened. Explosions, fires, major spills and major weather-related incidents—all of these are what BHP Billiton calls “material” risks.

“Within BHP Billiton Petroleum, our system is such that we not only identify potential risks, but we have to demonstrate on a regular basis how we are managing them,” says David Jenkins, head of Health Safety and Environment (HSE) for the Conventional petroleum business.

“Our risk management process begins with monthly reviews of a specified material risk and associated critical controls at the Operations level of each business unit,” Jenkins says. “One month later, all Conventional Petroleum general managers participate in a consolidated review of similar material risks with Asset President Steve Pastor to discuss the effectiveness of critical controls at each operation. The following month, Pastor and his team review the results with the president of Petroleum and Potash, Tim Cutt. And the month following that, Cutt has the same in-depth discussion with BHP Billiton’s CEO, Andrew Mackenzie. This means there is a deep and meaningful line of communication on how well we are managing our material risks, and the areas requiring improvement. That information flows in a structured fashion from the field all the way up to the CEO.”

At the field level, there is also a system custodian—typically an onshore engineer—who is responsible for each piece of critical equipment on the facility. For example, firewater protection, the subsea isolation valves, pressure relief valves and so on—each of these systems has a custodian. Those individuals are accountable for monthly reviews of any work that is needed or completed on the equipment. “Site champions” are the system custodians’ eyes and ears offshore. Site champions work directly with their system custodians to resolve maintenance issues.

“When you bring all of these things together, you have a very robust integrity management process,” Jenkins says. “It is one of the reasons that BHP Billiton is able to safely deliver the uptime performance and efficiencies that it does. It is because we have the processes in place that tell us whether or not we are in control.”

BHP Billiton’s senior executives know what is going on at the field level, and they give their full and consistent support.

Rachel Archer manages Operations for the Shenzi field.
"That makes the lives of the front line supervisors a good deal easier," adds HSE manager Sean Gallagher. "If field supervisors need to stop a job or slow it down for a safety and sustainability reasons, they have got ultimate support of management. Over time, the workforce has seen and embraced this, too. It is something that we practice every day."

"We are very proud of our safety culture offshore, says Rachel Archer, Operations manager for BHP Billiton in the Gulf of Mexico. "We set high expectations, and the feedback we get when our service providers work on our facilities is that they value the visit, because they really feel that their safety and well-being is extremely important to us."

**Critical Controls**

Jeremy Burford heads a group of engineers in a variety of disciplines. Together with technicians onboard Shenzi, they provide a line of defense against mechanical breakdowns and risks to the people working offshore.

"We’re responsible for all the critical controls," Burford explains. "We make sure all the equipment is functioning properly and tested on a regular schedule. The active fire protection system is one example. For that, we have various ways to mimic the response to a fire on the platform. We test the fusible plug loop by bleeding it down to make sure the pressure switch activates the firewater pump and the alarm. Some of our control verification work is driven by regulations, but we often do more than what’s required."

Burford’s team is also responsible for the design and execution of facility improvements, which requires interfacing with offshore operations.

"Whatever needs to be done, we work with the offshore team to plan and execute the work," Burford says. "We’re an integrated team. Our goal is to have a safe operation with maximum uptime. Excluding storm delays, we’re up and running 95 percent of the time. I believe that’s the best performance in the industry."

**Feedback From the Field**

Experience tells us that many of the best ideas for improving the safety and efficiency of high-risk jobs comes from the people who perform the work. The crews that maintain, load and transport the goods used offshore set a great example.

"We listen to our front line workforce and encourage them to speak up," says Graham Taylor, Material and Logistics manager. "The Fourchon shore base is a self-contained unit, so that is part of the story as well. These guys work as a team, and the quality of their suggestions is all the proof we need."

One of the most common oilfield hazards is when workers have to walk over pipes. The danger is worse when the pipes are racked on the deck of a moving ship, transporting that pipe to the drilling vessels. To reduce the risk, the workers at Fourchon came up with an idea that has since been adopted by many companies worldwide.
BHP Billiton designed and fabricated a new way to stack pipe so workers would not have to climb on top of the stacks and walk on the rounded, uneven and sometimes slick surfaces, often at heights of over six feet. This new pipe rack with passageway saved crews from having to walk on or work under pipe during lifting operations and rigging. Other operators in the Gulf of Mexico have adopted the same system.

The design was beautifully simple: build a pipe rack with a passageway down the middle. BHP Billiton fabricated a prototype, and Fourchon’s users refined the idea. They elevated the platform floor and made other refinements to improve pipe loading and unloading operations offshore. Further modifications allowed the pipe racks to fit the various widths of supply-vessel decks.

“We were convinced that it worked,” Taylor says. “BHP Billiton then commissioned additional pipe rack systems for all of its supply vessels, and other companies have since done the same. It is possible the design will someday soon become the industry standard.”

**Confined Space Entry**

Another common hazard is the need to clean the insides of tanks after each use to prevent the cross-contamination of drilling fluids. At Fourchon, the close collaboration between BHP Billiton crew members and a tank-cleaning company resulted in a simple, creative way to significantly reduce the number of times a worker would have to enter such confined spaces. The solution was a quickly deployed framework of pipes and nozzles.

“Before we implemented the cleaning system, personnel were spending about 26,000 hours per year in confined spaces, using hand-held high pressure sprayers to manually clean the tanks,” Taylor says. “The lightweight system the workers designed reduced the amount of time they now spend in confined spaces by 95 percent. We also experienced a 345,000-barrel reduction in waste water disposal, which is saving the company $3.7 million per year.”
The BHP Billiton Charter

“Our purpose and values, and how we measure our success”

BHP Billiton’s Charter is the single most important means by which the company communicates who it is, what it does, and what it stands for as an organization. It is the basis for all decision-making.

“We are BHP Billiton, a leading global resources company. Our purpose is to create long-term shareholder value through the discovery, acquisition, development and marketing of natural resources. Our strategy is to own and operate large, long-life, low-cost, expandable, upstream assets diversified by commodity, geography and market.”

Our Values:

• Sustainability – Put health and safety first. Be environmentally responsible and support our communities.
• Integrity – Do what is right and do what we say we will do.
• Respect – Embrace openness, trust, teamwork, diversity and relationships that are mutually beneficial.
• Performance – Achieve superior business results by stretching our capabilities.
• Simplicity – Focus our efforts on the things that matter most.
• Accountability – Define and accept responsibility, and deliver on our commitments.

We are successful when:

• Our people start each day with a sense of purpose and end the day with a sense of accomplishment.
• Our communities, customers and suppliers value their relationships with us.
• Our asset portfolio is world-class and sustainably developed.
• Our operational discipline and financial strength enables our future growth.
• Our shareholders receive a superior return on their investment.
People get there by helicopter… and supplies by boat

A crane hoists supplies aboard the Shenzi platform.
Community Support

Still tied to the land by supporting the folks back home.

Shenzi and Neptune may be 190 kilometers (120 miles) offshore, but BHP Billiton is committed to making a positive contribution onshore where its people live and work. In 2014, this took many forms in Louisiana alone where the company sought to be a good neighbor by supporting several initiatives emphasizing health, the environment and education.

**United Way for South Louisiana** The Shenzi, Neptune, Shorebase, and Heliport teams had 100 per cent participation, helping raise more than $100,000 in total BHP Billiton contributions for Chez Hope, Inc., Reach Out and Read, and Claire House.

**LA 1 Coalition** This coalition coordinates and disseminates public information to improve the Louisiana 1 Highway — a critical roadway in southern Louisiana — including repairing and rebuilding certain sections.

**Nicholls State University – Petroleum Engineering Technology and Safety Management Program** Designed for the offshore worker, graduates are elevated to management positions in safety and drilling and production operations, or they take up service and supply positions in the industry.

**South Louisiana Wetlands Discovery Center** This 2.4-acre property in Houma is being developed to include a nature exhibit, science building, amphitheatre, exhibits and research halls. BHP Billiton donated to the organization’s annual Wetlands Youth Summit.

Rachel Archer (far left) and her team are all smiles when it comes to helping out the United Way.
BHP Billiton donated $440,000 over three years to support an innovative early literacy initiative across northwest Louisiana as well as in Lafourche and Terrebonne parishes. An additional PRIME TIME “Plus” Preschool pilot initiative, incorporating nutritional awareness and healthy lifestyle promotion, is also being supported at $100,000 over two years.

Second Harvest Food Bank Second Harvest Food Bank of Greater New Orleans and Acadiana helps lead the fight against hunger, and builds food security in south Louisiana by providing food access, advocacy, education and disaster response.
Operational Integrity

Finding new ways to keep production levels high

From the earliest stage of the Shenzi development to six years after first oil, there was always a healthy tension between members of the project team. In biweekly meetings, they were encouraged to speak up, to challenge “the normal way” and offer fresh ideas. That dynamic of connection and collaboration has unlocked Shenzi’s potential. In many ways, it is part of Shenzi’s success.
**Strong Business Partners**

“The teamwork and collaboration extends through Hess and Repsol as well,” says Kristen Ray, general manager of BHP Billiton’s Gulf of Mexico operations. “They provide a lot of valuable input through our technical committee meetings. Hess and Repsol offer the kind of feedback that keeps us on our toes.”

Shenzi produced its first 100 million barrels of oil in 31 months, and it took only slightly longer than that to reach the 200 million-barrel milestone. Helping to achieve such a high level of performance was the platform’s ability to produce at close to its nameplate capacity for the entire six years. In January 2015, the Shenzi team and its business partners gathered in Houston to celebrate the occasion.

“We would like to recognize the enormous effort required across all functions to achieve this major milestone with excellent safety and environmental performance,” said Hess Corporation’s Rene Frederiksen.

Repsol’s Geoff Whiteley added that “BHP Billiton is one of the few partnerships that I have been involved with over the years that engages their partners and is open to suggestions and ideas. As Repsol was new to the deepwater arena in the early 2000s, we have been lucky enough to learn from the best. Repsol is proud to be a partner in Shenzi.”

**Twenty Percent More Oil With No Capital Cost**

In mid-2012, Shenzi’s production rate was 95,000 barrels per day and declining. At that point, leadership challenged the Shenzi production optimization team to establish the field’s unconstrained potential and find ways to maximize production. The combined team comprising production engineering, surface engineering, and operations surprised everyone when it announced it could boost the daily production rate significantly—and do so with little to no capital investment.
“Our team is very much results-driven. We focus on performance from the highest levels down.”

The team found four areas for improvement: gas handling, reducing pressure limits on wells, removing constraints on the platform’s inlet facility, and optimizing the alignment of wells into the subsea pipelines. Senior production engineer Collins Akajagbor developed computer-based nodal analysis models to evaluate the performance of each well instantaneously at a defined frequency.

“With these well models, we were able to see how each well contributed to the system in real time,” said production engineer Derek Cooper. “We could try things with the field’s configuration to see if they had an instant impact. We consistently challenged the status quo. Now we have a culture where every day, we take it upon ourselves to be better than the previous day.”

The facilities review team addressed a problem that had existed since startup. The Shenzi platform had two large natural gas compressors designed to operate in parallel. The design was sound, but the matched pair of compressors vibrated excessively if both were running at the same time. Operators had come to believe that the problem could not be solved without excessive cost.

A breakthrough came when rotating equipment engineer Alex Jablonski identified a modification that allowed both main gas compressors to operate simultaneously without vibration issues. With only one compressor in service, there was capacity for only 33 million standard cubic feet of lift gas per day (scf/d). The second compressor boosted the amount of available lift gas by 25 million scf/d. Injecting that extra volume of gas into the flowlines substantially reduced well backpressure, which in turn allowed more reservoir fluids to flow into the wells. Field operations, surface engineering, and production engineering teams then worked together to fine-tune the system. That one modification added some 15,000 barrels to the daily production. In 2015, Shenzi was still producing at a higher rate than it was when the facilities review process started in 2012.

“Besides the teamwork and collaboration, I’m impressed by the way we decide what to do next,” Ray says. “There is still a lot of potential to unlock with Shenzi. We will continue to optimize our water injection. We will continue infill drilling for at least the next two years, and we’re evaluating what opportunities that new technologies might offer for our field.”
Industry leader in drilling

Note: Deepwater Gulf of Mexico, sub-salt, post-moratorium
Sources: Rushmore, Offshore Oil Scouts Association (OOSA), BHP Billiton analysis

Shenzi productivity best-in-class

Note: Deepwater Gulf of Mexico, standalone facilities, average throughput vs. nameplate
Sources: Wood Mackenzie, BHP Billiton analysis

BHP Billiton’s Performance and Capability is Second to None
Drilling Ahead

One of the most advanced drill ships in the world is on station now.

Transocean’s ultra-deepwater drill ship Deepwater Invictus arrived in the Gulf of Mexico in May 2014 to replace the C.R. Luigs. In July, it began drilling on Atwater Valley Block 618 in 1,909 meters (6,266 feet) of water. Invictus moved from there to the Shenzi field in late 2014, where it delivered top-quartile performance in drilling its first Shenzi production well. Plans call for Invictus to be used primarily to drill water-injection and infill-development wells, and for exploring the northern part of the field. Beyond that, the Invictus could be available for exploring new fields both within and outside of the U.S. Gulf of Mexico.

The dynamically-positioned Deepwater Invictus can drill a 12,000-meter (40,000-foot) well in 3,650 meters (12,000 feet) of water. The fact that it was secured with a three-year contract shows that BHP Billiton is committed to ultra-deepwater development in the Gulf. Two features make Invictus especially suited for the job.

A Double Derrick and Twin BOPs

After the Macondo well accident in 2010, new U.S. laws required that the blowout preventers—the massive devices used to contain downhole pressures during drilling operations—be maintained,
inspected, tested and independently re-certified after each new well. The maintenance and verification associated with these requirements can take up to three weeks.

“The Invictus and other new deepwater drillships now include a second BOP onboard,” says Andy Reed, senior drilling engineer manager for Conventional Drilling, who was involved in the post-Macondo drilling at Shenzi and Neptune. “While the cost of the extra equipment adds to the vessel’s day rate, having the second BOP available shaves about two weeks off the turnaround time between wells.”

The Invictus’ main derrick, located amidships, has a capacity of 2.5 million pounds. An auxiliary drawworks and topdrive make it two derricks in one.

“That makes drilling much more efficient,” Reed explains. “While one derrick is being used to drill the well, the other can make up triple stands of casing that are racked in the second derrick. For open-water locations, as soon as the drill string comes out of the hole, the ship moves over a few meters and crews can begin running the surface casing. The ability to work offline is very important to us.”

**A Legacy of Success**

The C.R. Luigs was with the company for more than fourteen years, and in that time it drilled most of Shenzi’s wells. Although only a handful of the people onboard were BHP Billiton employees—the HSE and Drilling supervisors for example—the ship and its entire crew were very much a part of BHP Billiton’s culture.

“The good news is that some of the BHP Billiton supervision from the C.R. Luigs and Development Driller I are now working aboard Invictus.”
Jos Russell, vice president of Conventional Drilling.

“We had the Luigs drillship and a newer, semi-submersible ultra-deepwater rig called the Development Driller 1,” Reed says. “The Luigs felt like part of the company, so it was a sad day when we had to let it go. The good news is that some of the BHP Billiton supervision from the C.R. Luigs and Development Driller 1 are now working aboard Invictus.”

Gulf of Mexico general manager Kristen Ray adds that in 2015, Invictus could begin drilling a near-field exploration well. “That part of the field has yet to be tested,” she says. “We are very excited about what that might bring for the future of Shenzi. This is potentially the next phase of development.”

**The Drilling Group**

BHP Billiton is consistently one of the top drilling organizations in the industry.

“Besides our experience in the U.S. Gulf of Mexico, we’ve drilled deepwater wells offshore Australia, Angola, Gabon and Malaysia,” says Jos Russell, vice president of Conventional Drilling. “We’ve drilled in the Bering Sea, Indonesia, the North Sea and all over Australia. "After each new well, we review every aspect of the job to see what we can do better the next time. We work at it every day, fine tuning the process. I believe that kind of thinking is what gives BHP Billiton its edge.”
With its hull having arrived from South Korea, Shenzi’s topsides were fabricated by Kiewit Offshore Services in Ingleside, Texas.
A Global Footprint

BHP Billiton operates in some of the finest regions in the world for oil and gas opportunities. With its large, advantaged, and flexible resource base, the company believes its success is scalable and can be replicated.

HEAD OFFICE

Houston, Texas

OPERATED

1. **Onshore US (<1–100%)**
   - Liquids and gas production from shale fields in Texas, Louisiana and Arkansas.

2. **Gulf of Mexico – Neptune (35%)**
   - A permanently moored tension-leg platform that produces oil and gas.

3. **Gulf of Mexico – Shenzi (44%)**
   - A stand-alone tension-leg platform that produces oil and gas.

4. **Trinidad and Tobago – Greater Angostura (45%)**
   - An integrated oil and gas central processing platform.

5. **Pakistan – Zamzama (38.5%)**
   - An onshore gas and condensate development in the Sindh Province, Pakistan.

6. **Australia – Stybarrow Venture (50%)**
   - An FPSO facility producing oil and gas from the Stybarrow and Eskdale fields.

7. **Australia – Pyrenees Venture (40–71.43%)**
   - An FPSO facility producing oil and gas from the Crosby, Stickle, Ravenworth, Moondyne, Wild Bull and Tanglehead fields.

8. **Australia – Macedon (71.43%)**
   - A domestic gas development with a stand-alone gas plant.
   - First production achieved in August 2013.

9. **Australia – Minerva (90%)**
   - An offshore gas field and plant producing gas and condensate.

10. **United Kingdom – Bruce (16%) / Keith (31.83%)**
   - Offshore North Sea oil and natural gas production.
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Offshore North Sea oil and natural gas production.

EXPLORATION

Western Australia  India
Gulf of Mexico  South Africa
Southeast Asia  Trinidad and Tobago

NON-OPERATED

11. Gulf of Mexico – Mad Dog (23.9%)
A permanently moored integrated truss spar facility producing oil and gas.

12. Gulf of Mexico – Genesis (4.95%)
A floating cylindrical hull (spar) producing oil and gas.

13. Gulf of Mexico – Atlantis (44%)
A permanently moored semi-submersible platform that produces oil and gas.

14. Africa – ROD Integrated Development (38%)
Development and production of six oilfields located onshore in the Berkine Basin, Algeria.

15. Australia – North West Shelf (8.3–16.7%)
Supplies oil and gas to Australian and international markets.

16. Australia – Bass Strait (50%)
20 producing oil and gas fields with 23 offshore structures.
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Halliburton – Faster, safer drilling in deepwater Gulf of Mexico

Halliburton is a leading global provider of oil field services and equipment. In the Gulf of Mexico, Halliburton has advanced drilling technologies which apply from the continental shelf to deepwater and into ultra-deepwater. The BHP Billiton Shenzi development is in deepwater, approximately 1340 meters (4400 feet). It required technologies from Halliburton’s integrated suite of solutions.

The Shenzi field achieved first oil in 2009; Halliburton’s scope of work included the exploration, appraisal and initial production wells. As the field has matured, the work expanded with the additional production wells and, more recently, the world’s deepest water injection wells. Over the life of the field, Halliburton has helped design and drill 32 wells for the Shenzi development. BHP Billiton and Halliburton share the common objectives of safety and preserving the environment, which extends throughout the relationship.

Drilling

On the Shenzi project, BHP Billiton and Halliburton achieved record well drilling times using state-of-the-art technologies.

The industry has drilled more than 100 subsalt wells in the deepwater Gulf of Mexico. Halliburton’s technology has helped BHP Billiton consistently achieve the best drilling speeds of less than two days per 305 meters (1000 feet) on many of their wells (see graph).

Among the greatest contributors to this success is Halliburton’s ACCOLADE drilling fluid technology system. The ACCOLADE fluid is an organophilic, clay-free invert emulsion drilling fluid with excellent lubricity characteristics. It reduces drag on the drilling string and required torque allowing more weight-on-bit resulting in greater drilling speed. It has been used on over 350 wells in the Gulf of Mexico. This technology has led to a family of organophilic clay-free drilling fluid systems and products.

VersaFlex Big Bore system, another drilling technology utilized for the Shenzi project, enabled the operator to set casing at a desired depth. Additionally, it created a double barrier that meets new government regulations.

These key technologies, and the collaboration of the well engineering design and execution teams of BHP Billiton and Halliburton, have achieved enviable drilling results in the deepwater Gulf of Mexico.

Completions

BHP Billiton selected Halliburton’s world-class completion technologies and highly trained delivery specialists for the Shenzi development.

One of the key technologies was the Beyond Red Zone (BRZ) Frac System. This system uses special hardened material to minimize erosion of the steel when pumping either a high volume of sand (proppant) or at a high stimulation rate, or both, into a well. Using the system, the Shenzi project set a Gulf of Mexico record with a perforation interval of more than 131 meters (430 feet) at a rate exceeding 60 barrels per minute (BPM). This system was especially important since a number of Shenzi wells had perforation intervals greater than 76 meters (250 feet) and required more sand volume. The ability to pump long intervals, and at a high rate, enabled the zone to be treated on a single trip, eliminating multiple days of rig time.

Another key Halliburton technology used was the AquaLinear fluid service to enable better production. The process includes pre-fracture sandstone acid treatments of the well bore, then a crosslinker to prevent damage to the reservoir. The result was a consistently low skin on the wells and better than expected production rates.

In order to prevent fluid loss into the reservoir, Halliburton installed remotely operated FS and IB mechanical valves. In addition, these valves enable easier well maintenance activities.

Although not used on Shenzi, Halliburton has other solutions to improve offshore projects. One that benefits reservoirs with multiple pay zones is Halliburton’s Enhanced Single-Trip Multizone (ESTMZ™) system. It allows up to five zones to be perforated and stimulated without having to pull the service tool out of the hole, saving significant rig time.

The Gulf of Mexico is a growth area for the industry. Opportunities are expanding further with the opening of offshore areas by Pemex. Halliburton and its technologies are ready to help the industry expand and develop more reserves.

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MMR Provides Electrical and Instrumentation Expertise on Shenzi TLP

The Shenzi platform required enough electrical power to support a small city. MMR Group, Inc. was enlisted to design and install Shenzi’s electronic instruments and control systems.

MMR has been recognized as an industry leader for over 50 years in electrical and instrumentation (E&I) construction, maintenance and technical services. MMR has experience in serving oil and gas clients, in both onshore and offshore settings, in 34 countries. As the largest open-shop electrical and instrumentation contractor in the nation, MMR has over 20 branch offices in North and South America.

MMR has provided E&I services for power generation, chemical and petrochemical, oil and gas, industrial and manufacturing facilities around the world, including oil sands projects in Canada, automobile factories in Asia and BHP Billiton’s sister projects, Atlantis and Mad Dog. MMR has performed over 50 major production platform projects in the Gulf of Mexico, Caribbean and South America over the last 20 years.

MMR constructed and installed the power and control systems for the topsides module of the Shenzi TLP, which included pneumatic instruments, performing loop checks and high-voltage testing, fabricating panels and start-up assistance and commissioning.

The onshore work was completed at the Kiewit fabrication yard in Ingleside, Texas. The strategic location of MMR’s Offshore Services Division in Ingleside, allowed project managers and installation specialists to mobilize quickly and coordinate with the project schedule during topsides fabrication.

Once the Shenzi TLP was installed offshore, MMR crews were among the first aboard to tackle a myriad of system connections, control calibrations and start-up of “working end” systems. Function testing was then performed to certify that all MMR installed components were operating as designed. MMR has a continuing relationship with Shenzi through a Master Services Agreement to perform E&I services as requested.

On all of its projects, MMR requires team performance and personal accountability. This is MMR’s best practice to ensure safe and quality results on every project. For example, management has a “Zero Tolerance Policy” for violating proper safety protocols. Team members are expected to immediately stop any unsafe activity and initiate corrective actions. Result—the onshore and offshore work on Shenzi was completed without a lost time accident.

MMR’s attitude for safety is also recognized by OSHA. The MMR Corpus Christi site is one of only 12 of the 76,000 electrical contractors in the nation to have achieved an OSHA Voluntary Protection Program (VPP) designation for injury and illness rates below the national average.

“We were pleased to partner with BHP Billiton on such an incredible project for the oil and gas industry,” said MMR President and CEO Pepper Rutland. “Through a culture of safety and unwavering commitment to quality, efficiency and client satisfaction, MMR is proud to have contributed to the overall success of the Shenzi project.”
Performance Energy Services (PES) was formed in Houma, Louisiana, in 2000, and specializes in piping and structural fabrication and offshore hook-up. PES has been involved throughout the life-cycle of the Shenzi project.

The first support to BHP Billiton was helping in the Shenzi installation leading to first oil in 2009. PES was selected as the offshore hook-up contractor for the Shenzi Tension Leg Platform (TLP) installation in 2008 after successfully completing similar work for BHP Billiton’s Angostura project in Trinidad from 2004 through early 2005. PES key personnel were part of the planning and integration team at the fabrication contractor, Kiewit’s facility in Ingleside, Texas. That process ensured that everything was ready for the offshore mechanical hook-up phase that was mobilized in the 3rd quarter of 2008. PES’s installation scopes of work included all interconnect piping, structural components and any fabrication of components for the top-sides. The quality of work that PES delivered was critical for the teams to achieve authorizations to start up the facility. The Quarter’s Habitable (QH) certification from the Coast Guard was the first milestone of the offshore campaign, and allowed personnel to live and work on the platform. Mechanical completion and assured hydrocarbon readiness were essential to achieve the Coast Guard’s Certificate of Insurance to begin start-up. The American Bureau of Shipping’s (ABS) consent was also required for the marine systems. PES also assisted in all areas, from procurement of materials and third party services to the final commissioning and start-up.

PES lifecycle support for Shenzi continued when they were chosen by BHP Billiton as the contractor for the Phase II Water Injection Project for the Shenzi field. The PES project management team’s responsibilities included the execution plans, work packs, fabrication, procurement of piping, structural materials, valves and specialty items. PES also handled technical queries, materials management and detailed weekly reporting. Project phases included procurement, fabrication and installation of a CIP (Clean in Place) water storage system. The CIP system comprised two 72”-diameter x 142’-tall duplex steel modular tanks installed inside the TLP hull column. The project also included the installation of two...
solar turbines, a 75-ton pump manifold platform, multiple equipment packages and fabrication of all associated structural and piping components. The water injection project had strict materials requirements, with over a dozen different grades of steel and exotic alloys being used in the piping fabrication process alone.

BHP Billiton has always been a progressive and supportive partner and is typically ahead of the curve on implementing improved safe work practices and management systems. Policies they enforced on Shenzi are now being acknowledged as industry standards. BHP Billiton’s culture of continual improvement and teamwork has forged the foundation of the working relationship with PES that has been extremely successful over the past 10 years.

Performance Energy Services has also provided mechanical, construction, electrical, instrumentation and management services for BHP Billiton’s Neptune and West Cameron 76 fields in the Gulf of Mexico and the Douglas facility in the UK sector. In 2014, PES significantly enhanced its relationship with BHP Billiton with a large-scale project in the onshore Eagle Ford shale development.

PES has an extensive Gulf of Mexico Deepwater portfolio with William’s Gulfstar 1 FPS serving Hess’s Tubular Bells field, ATP’s Titan, and both of LLOG’s deepwater facilities—Who Dat and Delta House. All were successfully installed and placed in service since 2010. In addition, PES has completed thousands of smaller projects over the past 15 years.

The PES international resume includes the installation of BHP Billiton’s Angostura project in Trinidad, Samedan’s Amistad facility in offshore Ecuador, Noble Energy’s Tamar platform and field development in Israel. PES has also successfully completed dozens of major facility upgrades and construction projects in West Africa, the Caribbean, South America, Europe and the eastern Mediterranean.

In October of 2013, Performance Energy was acquired by Quanta Services, a leading provider of full-service engineering, procurement and construction (EPC) services for the energy infrastructure industry; electric power, oil and natural gas, and fiber optics. With PES, Quanta Services expands its presence in the offshore infrastructure of the oil and gas industry. Quanta Services has the knowledge and expertise to handle a full spectrum of onshore, offshore and international projects. Quanta and PES are both aligned with a safety culture. Together, they can safely, efficiently and cost-effectively deliver energy infrastructure projects globally.
OneSubsea’s Pore to Process™ approach helps optimize production and recovery

OneSubsea™ is a unique company, launched in mid-2013 by two subsea leaders, Cameron and Schlumberger. OneSubsea delivers integrated solutions, products, systems and services for the subsea oil and gas market. The company offers a step change in reservoir recovery for the subsea oil and gas industry through integration and optimization of the entire production system over the life of the field. OneSubsea combines Cameron’s flow control expertise, process technologies, and world-class manufacturing and aftermarket capabilities with Schlumberger’s petrotechnical leadership, reservoir and production technology and R&D capabilities. OneSubsea’s unique Pore to Process™ offering helps provide end-to-end solutions from the reservoir to the surface that address client challenges with the goal of optimizing production and increasing recovery.

OneSubsea production systems have been installed worldwide in many different subsea environments. The products are recognized globally as being technologically advanced and highly reliable, both of which are critical to safe and cost-effective operations. This reputation for excellence and an extensive history of successful partnerships made OneSubsea, through legacy Cameron, the logical choice to provide subsea production equipment for the Shenzi field, operated by BHP Billiton, in the deepwater Gulf of Mexico (GOM).

Shenzi field characteristics

The Shenzi field is located approximately 120 miles from the Louisiana coast in the Green Canyon block of the GOM and has water depths of 1.31 km (4,300 ft). Shenzi is estimated to hold recoverable reserves of 350 to 400 MMboe/d. The operating facility is a tension leg platform capable of producing 100,000 b/d of oil and 50 MMcf/d of natural gas. Production began in March 2009 and currently, there are 21 wells in production.

Field development

Field development began in 2006, and included OneSubsea horizontal SpoolTree™ systems, manifolds and well jumpers.

OneSubsea provided horizontal SpoolTree™ systems for development of the Shenzi field.

For the first phase of the Shenzi development, OneSubsea provided seven horizontal SpoolTrees rated to 10,000 psi and 121.1°C (250°F). Additional equipment included

- Five 4-slot manifolds
- 5-in and 7-in FLS® gate valves
- 6-in and 10-in CVC™ connectors and hubs

The horizontal SpoolTrees offered by OneSubsea can be operated in shallow or deep water and rated from 10,000 and 15,000 psi. OneSubsea horizontal trees are designed such that they provide the following benefits to the operator:

- Enable tubing completion and workover activities to be performed under full BOP protection, reducing rig times
- Eliminate the need for a dual-bore workover and completion riser system
- Allow the tubing hanger to be pulled without removing the tree

For the second phase of the Shenzi development, OneSubsea was again selected to provide equipment. An additional eight 10,000-psi horizontal SpoolTrees and associated production hardware were installed, which included

- Four 4-slot manifolds
- 5-in and 7-in FLS gate valves
- 6-in and 10-in CVC connectors and hubs

In 2009, the Shenzi Water Injection Project was awarded to OneSubsea. This project is designed to process 125,000 bbl/d of seawater for injection into the reservoir. An initial order for three horizontal SpoolTrees and project scope included

- 2 Water injection subsea tree systems
- 2 Subsea tree conversion kits
- 5 Solid INCONEL® tree tubing hangers
- 9 Manifold valves
- 12 CVC connectors and hubs

Manufacturing, assembly, and testing of all equipment for Shenzi Water Injection were supported by OneSubsea facilities in Johor, Malaysia; Leeds, England; and Berwick, Louisiana.

OneSubsea has provided equipment from its product technology suite for other projects operated by BHP Billiton, such as the Pyrenees and Macedon fields offshore Western Australia. OneSubsea designed and delivered 18 complete subsea systems for Pyrenees. For Macedon, OneSubsea provided the production system, manifold valves and a state-of-the-art control system that uses fiber optic communication lines to transmit data to and from subsea equipment to the control room.
Shenzi – Success from Collaboration between Partners

Repsol launched its foray into the Gulf of Mexico with the 2006 acquisition of its interest in the Shenzi Field. Looking to capitalize on its deepwater exploration expertise and build up its portfolio in a high-potential area, Repsol focused on the U.S. — and the Gulf of Mexico specifically — as a strategic growth area.

Partnering with BHP Billiton, Repsol embedded key personnel in the project team to collaborate on reservoir characterization and as an integral part of the facilities’ design team. The Shenzi development plan was complex, not only because of the 4,300-feet water depth, but also because it called for a water injection phase that included the deepest water injection wells in the world, more than 28,000 feet of total vertical depth. This challenge required creative thinking and BHP Billiton welcomed input from its partners.

“BHP Billiton is an excellent partner,” said Geoffrey Whiteley, Repsol’s Shenzi Field Manager. “They are a superb operator with an outstanding safety and environmental record. As operator, they bring a tremendous amount of deepwater technical expertise to the partnership. They are very receptive to our input, and this collaborative approach has allowed us to provide ideas which have resulted in improvements.”

Shenzi Optimization

These collaboration efforts proved successful in arresting the field’s decline. The steady production rate has been the result of well placement, production initiatives, and optimal completion practices. The water injection project is also having a positive impact on production. Although the deepest water injection wells created unique and unpredictable challenges, the collaborative management style allowed the team to identify and successfully implement solutions. That process is setting technical standards for future deepwater injection wells, while maintaining production levels.

As the understanding of the Shenzi Field increased, the partnership identified additional opportunities in the area. They acquired the Genghis Khan Field, which is geologically linked with Shenzi, and will continue to expand the hydrocarbon footprint northward in 2015 with an exploration program.

Repsol’s North American Strategy

Repsol’s upstream business is the company’s growth engine, and the Gulf of Mexico is a key area. In 2014, Repsol’s Leon discovery in ultra-deep water found a high-quality net oil deposit. In addition, Repsol drilled a second well to appraise its 2009 Buckskin discovery with positive results. Repsol is maturing several other deepwater Gulf of Mexico prospects which, together with an appraisal well for the Leon discovery, will be part of its next operated drilling campaign.

Elsewhere in North America, Repsol is drilling three exploration/appraisal wells in 2015 in Alaska to expand on its recent exploration success on the North Slope. Repsol also is developing unconventional resources in the Mississippian Lime in Kansas and Oklahoma.

In December 2014, Repsol signed an agreement to acquire Talisman energy, and aims to close the transaction in the second quarter of 2015. The deal will transform Repsol into one of the world’s largest energy companies, and expand its North American presence to represent more than half of the company’s total.
NACHER & MISTRAS – Maintaining the Integrity of the Shenzi Asset

NACHER Corporation was founded in 1991, as a multi-discipline turnkey service provider of maintenance and inspections for the oil and gas, offshore, and petrochemical industries. NACHER was acquired by MISTRAS Group in August 2014. The acquisition strengthened both companies; reinforcing the offshore capabilities of MISTRAS Group and broadening NACHER’s comprehensive service offerings. MISTRAS Group and NACHER have solidified the relationship with BHP Billiton with a more comprehensive technical support for on- and offshore projects.

NACHER’s offshore testing, inspection, and repair services are typically conducted on platforms, and often at height, using powerful repair or corrosion management equipment. NACHER utilizes the capabilities of MISTRAS Group, providing a variety of expert training, non-destructive evaluation (NDE) and testing (NDT) services. These services use a variety of technologies and techniques, such as digital radiography, ultrasonic testing (UT), rope access, and corrosion management solutions. Additional solutions include Enterprise-based Data Management software, on-line asset integrity monitoring systems and maintenance and construction services (flange torquing, ABS Certified welders, bolt tensioning, etc.).

NACHER relies on the training, experience and ability of their personnel to perform highly skilled and difficult tasks. To support those skills, NACHER operates a state-of-the-art training facility in Youngsville, Louisiana, specifically designed to accommodate rope access, safety procedures and rescue training simulations. The purpose-built facility allows NACHER’s workforce to continually develop and refine skillsets, creating value-added training opportunities in preparation for projects, planned maneuvers and equipment use. This training resource continually improves the safety of NACHER’s workforce for its projects, including successful work on the offshore BHP Billiton-operated Shenzi platform.

Initially joining the Shenzi team in 2013, NACHER helped maintain the integrity of BHP Billiton’s Shenzi asset, performing Ultra High Pressure (UHP) water blasting services to remove corroded areas on the cellar deck, and then applying a protective, heavy-duty coating on the deck substrate.

In recognition of the cellar deck project, NACHER has continued to provide mechanical integrity (MI) services on BHP Billiton’s Shenzi asset. The continuation of services has expanded to include ultrasonic (UT) and visual testing (VT) and assignment of Condition Monitoring Locations (CML) to regularly assess asset health in a particular location. Once CML’s are established, NACHER examines the asset’s external conditions by taking thickness measurement tests and stress and temperature thresholds, which help determine remaining life value and inspection intervals of the asset.

NACHER and BHP Billiton have similar policies and objectives that aid in the success of safe and incident-free operations. Safety is a NACHER cornerstone supporting its ability to provide quality and incident free work. NACHER’s safety protocols adhere to Occupational Safety and Health Administration (OSHA), American Petroleum Institute (API) and BHP Billiton’s proactive safety standards. NACHER’s continued involvement on the Shenzi asset has been completed without a lost-time incident due to common safety goals expressed by NACHER’s technicians and training personnel.

MISTRAS Group is a leading “one source” global provider of technology-enabled asset protection solutions that are used to evaluate the structural integrity of critical energy and industrial and public infrastructure. Mission critical services and solutions are delivered globally to provide customers with asset life extension; improved productivity and profitability; compliance with government safety and environmental regulations, and enhanced risk management operating decisions.

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