BP’s deepwater technologies
Introduction

BP’s history is inextricably linked with the deepwater. We were one of the first to move from the shelf in the Gulf of Mexico, and into deeper waters West of Shetland in the North Sea, twenty five years ago.

Since then we have transferred our deepwater expertise to Angola, Egypt, Brazil and Australia.

Without technology, the world’s deepwater provinces would not have been explored or developed.

>650
The number of leases held by BP in the Gulf of Mexico
DEEPWATER CHALLENGES

Few provinces offer the range and diversity of challenges we see in the deepwater. Without doubt, it is the most difficult environment in which we operate. Far from shore, physically cut off, in waters up to a mile deep. Often in extreme weather and inhospitable environments.

Operating in the deepwater inevitably incurs risk. Understanding the risk profile and establishing barriers and controls, is a critical component of our licence to operate.

Another key challenge facing our industry, but one particularly felt in the deepwater is the capital intensive nature of offshore developments, with long drilling durations, subject to short weather windows and often volatile local market conditions.

Deepwater provinces, like the Gulf of Mexico and Angola, are prolific in hydrocarbons, but achievable recovery rates tend to be lower than onshore because of fewer well penetrations. Drilling and maximising production from each deepwater well is therefore critically important.

Our technologies help face and overcome these challenges.

DEEPWATER TECHNOLOGIES

At BP we seek to be a leader in the areas where we can have the most impact for the resource holders with whom we partner. For deepwater, these technologies are:

+ Seismic imaging technologies, especially subsalt imaging
+ Digital technologies, to support drilling, production optimization and safety and integrity
+ Wells technologies, to support safe and efficient drilling
+ Subsea technologies, to protect production and access hard to reach hydrocarbons
+ Enhanced oil recovery technologies, to maximize economic recovery

Gulf of Mexico
+ Paleogene (sub-salt, complex overburdens, HP low permeability, higher viscosity)
+ Miocene (sub-salt, maturing portfolio, waterflood challenges)

UK / Norway
+ Sub-basalt (imaging challenges)
+ Gas prone
+ Maturing Infrastructure

Azerbaijan
+ Some HP long tie-backs
+ Gas prone

India
+ Gas (infrastructure challenges, distant from shore)
+ Small pools

South China
+ Gas prone

Australia
+ Gas
+ Large distances from demand regions (infrastructure challenges)

Egypt
+ Gas (mild-moderate water depth, HT 400°F, long tie-backs), HP
+ Small pools

Brazil
+ Complex carbonates (pre-salt, drilling in salt, well construction in carbonates, no analogue)

West Africa
+ Clastics (sub-salt, sand prone, smaller pools)
+ Recent carbonate discoveries in pre-salt

BP’s DEEPWATER TECHNOLOGIES | 03

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BP’s DEEPWATER TECHNOLOGIES | 03
Finding deepwater resources

Seismic data is our most important lens into the subsurface. It allows us to image the reservoir structure, provide valuable insights into the geologic model and design and manage optimal field developments.

DEEPWATER CHALLENGES

In many of the world’s deepwater basins, salt lies above hydrocarbon reservoirs. These salt diapirs act as seals to oil and gas migration, but they also produce distortive effects on seismic waves, making it difficult to image and characterize hydrocarbon-bearing reservoirs.

BP TECHNOLOGIES

BP’s seismic technologies have led the industry over the past fifteen years as we sought to break the trade-off between image quality and the cost of large-scale acquisition.

- **Innovative Seismic Acquisition**
  Wide Azimuth Towed Streamer, Multi Azimuth Towed Streamer, iSS® with Ocean Bottom Seismic, Ocean Bottom Nodes

- **Seismic Imaging & Modeling**
  Full Waveform Inversion, Synthetic Data Simulation

- **Seismic Reservoir Characterization**
  Integration Engine, 4D Seismic Tools and Workflows, Distributed Acoustic Sensing

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BP and CGG announced an R&D collaboration agreement in 2014 to develop the next generation of marine vibratory seismic sources.
**TECHNOLOGY DEPLOYMENT**

+ BP led the industry in subsalt imaging with Wide Azimuth Towed Streamer technology (WATS). WATS captures data from many azimuths and offsets to effectively bypass the salt. Since then we have deployed it extensively in the Gulf of Mexico and Angola.

+ We are evaluating how our simultaneous source technology, ISS®, works in the deepwater Gulf of Mexico, transferring experience from our recent offshore survey in Trinidad and the North Sea. ISS® technology makes large-scale 3D surveys faster and lower cost by using multiple sources surveying simultaneously with noise processed out.

+ In 2013, BP opened a new Center for High Performance Computing, a worldwide hub for processing and managing huge amounts of BP’s geologic and seismic data, dedicated to developing our industry-leading imaging R&D.

**FINDING | DEVELOPING | OPERATING | MAXIMIZING | OPTIMIZING**

**BP OFFER**

We have a solid track record in developing and deploying seismic imaging technologies to deliver high-quality images from deepwater basins, particularly those challenged by complex overburden, like salt.

We hold proprietary acquisition design and development algorithms and work with vendors on new equipment manufacture and operational deployment methods for rapid commercialization and implementation at scale.

In this way, we bring innovation and speed to market for the benefit of the resource holders with whom we work.

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120 km²
The survey distance BP undertook at water depths of 300-9000 feet in Canada

3,800 trillion
The number of calculations per second powering our Center for High Performance Computing
Deepwater developments

Today’s deepwater developments bear little relation to the first offshore platforms and wells. Technology and engineering have transformed how we drill, produce and operate from the deepwater.

Deepwater giants, like Thunder Horse in the Gulf of Mexico, house vast topsides, with equipment capable of processing 250,000 barrels of oil a day - from just twenty wells.

DEEPWATER CHALLENGES

The precision required to drill a mile below sea-level and three miles through rock makes deepwater drilling some of the most challenging in our industry.

Operating facilities under extreme pressures (physical load and downhole pressures) and temperatures (from within the reservoir and sea) test their capabilities.

As these facilities become more complex, loaded with more equipment, the trend is to reconfigure topsides and move more equipment subsea, which brings its own challenges.

BP TECHNOLOGIES

We develop, source and qualify new wells and facilities technologies that mitigate reduce risk, increase cost efficiency, sustain production and unlock barriered resources.

DEPLOYMENT EXAMPLES

+ BP operates one of the largest deepwater projects in Africa and indeed the world, in terms of water depth and subsea extension: Plutão, Saturno, Venus and Marte, known as PSVM. Major technology breakthroughs deployed are subsea flowline spool design, forgings, flexible riser installation and its enormous turret, with the largest swivel stack in operation.

+ BP Well Advisor focuses on optimizing well construction and supporting improved well operations. Its consoles have been extensively trialled in the Gulf of Mexico, as well as North Sea, Brazil and Azerbaijan, where we recognize both the economic and safety imperatives associated with deepwater drilling.

$200 million

The estimated value saved by Casing Running console to date across BP’s global operations

21,300 feet

The deepest well ever drilled in Egypt, by BP in the Eastern Nile Delta in 2015

BP OFFER

We bring deep expertise and insight in developing and deploying wells and subsea technologies globally. We have distinctive advantage in our strategic relationships and expert market knowledge to help us deploy the right solutions for the different challenges we face.
Operating safely

Technology plays a key role in delivering safety and integrity in deepwater environments.

DEEPWATER CHALLENGES

Weather, waves and temperatures exert incredible forces on deepwater facilities, and along with the corrosive effect of sustained seawater and hydrocarbon contact, and, without safeguards, they may impact long-term operational integrity. Assuring ourselves of facility integrity is much more challenging in the deepwater: manual inspection across vast, complex subsea developments is difficult. If integrity is compromised in any way, as responsible deepwater operators we need to be alerted immediately and equipped to take action.

BP TECHNOLOGIES

Our technologies support safe and reliable operations around the world:

- **Environmental Technologies**: Reducing operational impact on marine life, e.g. satellite telemetry, water & air quality management.
- **Inspection**: Non-piggable subsea lines, e.g. Digital Radiography; non-intrusive inspection, e.g. Permanently Installed Monitoring System.
- **Advanced Materials**: Performance and selection for HPHT, composites for subsea applications, performance limits of alloys.
- **Strengthening flow assurance**: Scale risk prediction, asphaltene inhibition, tagged scale inhibitor and modeling.
- **BP Well Advisor: Pressure Testing**: Displays, interprets and documents positive BOP and well barrier pressure tests in real time.
- **BP Well Advisor: No Drilling Surprises**: Displays correlation of sub-surface boundaries, zones of overpressure, and pre-drill risks, and provides real-time early warning indicators of sub-surface risks.
- **Smart Deployable Centraliser**: Manages effective zonal isolation.
- **Reduce souring risk**: Souring risk prediction, targeted biocide and enhanced chemical barriers, high efficiency H2S scavenging.
- **BP Well Advisor: Cementing**: Monitors real-time execution of cement jobs to support verification of cement well barriers.
- **BP Well Advisor: BOP Monitoring**: Remote monitoring of health and valve positions; simple diagnostic information.

**BP-INTERNATIONAL CENTRE OF ADVANCED MATERIALS**

The BP-International Centre for Advanced Materials is a partnership between BP and three universities to enable application of advanced materials to energy challenges.

**BP OFFER**

Our long history of operating in the deepwater informs our understanding of what it takes to work in this inhospitable environment – and how technology can help make a real difference.

We take safety and integrity extremely seriously as a responsible operator and actively seek ways to share our insight, expertise and technologies with our partners.
Maximizing recovery

We are driven by the mission of maximizing economic recovery from the fields we operate.

DEEPWATER CHALLENGES

Operating in the deepwater requires a continual focus on recovering every economic barrel. Waterflooding and gas injection are widely deployed in deepwater operations to maintain pressure, but both add incremental cost per barrel.

At BP, we focus on developing low-cost Enhanced Oil Recovery technologies to maximize value from the water and gas we inject.

BP TECHNOLOGIES

BP-operated EOR projects produce more than 10% of the world’s total conventional oil EOR production rate, more than any other International Oil Company.

**Designer Water® EOR**

- LoSa® EOR – a breakthrough reduced salinity waterflooding technology that increases oil recovery compared to conventional waterflooding
- Bright Water®: a microscopic, thermally-activated particle that expands deep in the reservoir, diverting injection water into poorly swept areas of the reservoir, thereby increasing oil recovery

**Designer Gas® EOR**

- Miscible gas injection to displace oil from the rock, often alternated with water injection to improve sweep, can improve recovery by 6% to 10% STOIP over base waterflooding
- Lean gas, such as methane, vaporizes oil from the rock surface and carries it to production wells, before being recycled

**Digital Rocks**

Applying next generation imaging, modeling and simulation technology to improve reservoir characterization and performance prediction

**EOR Labs**

- BP’s EOR laboratory is a sophisticated facility for conducting fluid flow studies in porous media
- The latest addition to our toolkit is the world’s first automated core flooding capability. This robot works 24/7, transforming the number of core floods from tens to hundreds a year.
TECHNOLOGY DEPLOYMENT

- Gas EOR extends the field life and adds reserves to offshore fields, for example, Ula in the Norwegian North Sea, where nearly 100% of current oil production is from EOR.
- The world's first deployment of LoSa® EOR will be at Clair Ridge in the North Sea - at a cost of $3/barrel.
- 140 wells treated with Bright Water® particles worldwide.
- Digital Rocks technology has been deployed across BP's portfolio to inform appraisal and optimize depletion planning.

OFFSHORE EOR TECHNOLOGY DEPLOYMENT

For more information on BP's Designer Water, Designer Gas & LoSa® EOR technologies please contact eor@bp.com or visit www.bp.com.

BP OFFER

We lead the industry in the deployment of non-thermal EOR technologies and deliver more than 10% of the world's light oil EOR production, more than any other IOC: these deployments include proprietary water-based EOR technologies and gas EOR, including deployments offshore of miscible gas at the Ula and Magnus fields in North Sea. We are the first to deploy LoSa® EOR in Clair Ridge in the North Sea, and are evaluating both this and other Designer Water® EOR technologies at many other deepwater fields.

LoSa, Designer Water and Designer Gas are registered trade marks of BP plc. Bright Water is a registered trade mark of Nalco Champion.
Optimizing deepwater production using digital technologies

The deepwater requires high levels of sustained production to deliver its return on investment.

DEEPWATER CHALLENGES

The high cost of developing and operating in the deepwater requires investment in deployment of a broad range of digital capabilities in our wells and facilities from day one, as well as the flexibility to adapt to new technology. Digital technologies in particular play an important role in sustaining high levels of operational efficiency through real-time design and support, but they generate massive volumes of data that need to be managed to create value.
BP TECHNOLOGIES

We employ a range of technologies to optimize production across the deepwater fields we operate. We call these our Field of the Future® technologies:

Advanced Surveillance and Monitoring
Well surveillance, including acoustic and temperature Sensing; Well integrity monitoring; and Facilities operation envelope monitoring, reporting and analysis

Modeling and Optimization
Data Visualization, Predictive Modeling and Optimization technologies. Automation: technologies that operate autonomously based on defined rules and structured information, e.g. Slug Controller, Auto Choke Bean Up

Operations Support
Drones, robots and GPS tracking for fleet logistics optimization and inspections

DIGITAL CENTER OF EXPERTISE MODEL

In 2014, BP established a global Digital Center of Expertise to bring together BP’s digital subject matter experts, data scientists and statisticians to develop, deploy and integrate a broad range of digital solutions across our global operations.

Measurement
systematic deployment of sensors

Transmission
digital connectivity from field to office

Analysis
analysis and predictive modeling of integrated big data

Interaction
‘next generation’ interfaces for complex information

Control
leading control systems with available interventions

BP OFFER

We have been operating in the Deepwater for three decades and understand its challenges. Our Field of the Future® program has been operating for more than 15 years and focuses on high rate, high cost offshore wells in the Gulf of Mexico, North Sea, Angola and Azerbaijan.

Our Digital Center of Expertise is the nexus of that experience in BP, as well as the center for all new R&D in this important area. It is this combination of technology and expertise that we make available to our partners in order to create mutual value.

1 million
The number of barrels of oil equivalent per day monitored by our Field of the Future® technologies in real time

1,750 kms
The length of fiber-optic cable linking BP’s operations with 35 Advanced Collaborative Environments (ACE) worldwide
BP’s deepwater technology offer

The Deepwater is often described as a frontier. Like all frontiers it involves risk and reward. BP’s technologies help mitigate some of the risk as well as capture more of the reward. They can help find more resources and optimize well placement, as well as maximize production and field recovery. Finally they deliver efficiencies in how we operate, which can lower cost and extend field life.

Houston, Texas is BP’s Deepwater Center: the home of our Facilities & Integrity R&D function, our state-of-the-art Wells Monitoring Center and our Center for High Performance Computing. It is also the headquarters of our Deepwater Response organization, where we continue to transfer know-how and expertise across our organization, and with our industry.

Each provides a window into a different aspect of our deepwater technology offer.

We look forward to sharing it with you.
For more information about BP’s deepwater technologies please visit our website bp.com/technology

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