Unconventional gas and hydraulic fracturing
Issue briefing

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How we operate

At BP, we recognize that we need to produce energy responsibly – minimizing impacts to people, communities and the environment.

We operate in around 80 countries, and our systems of governance, management and operation are designed to help us conduct our business while respecting safety, environmental, social and financial considerations.

Across all BP operations, established practices support the management of potential environmental and social impacts from the pre-appraisal stage through to the operational stage and beyond – reflecting BP's values, responsibilities and local regulatory requirements.

BP's operating management system integrates BP requirements on health, safety, security, social, environment and operational reliability, as well as maintenance, contractor relations, compliance and organizational learning into a common system.

BP participates in a number of joint venture operations, such as in Algeria and Indonesia, to extract unconventional gas. Some of these are under our direct operational control, while others not. When participating in a joint venture not under BP control, we encourage the operator of the joint venture, through dialogue and constructive engagement, to adopt our practices.

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Cover image
BP's gas well drilling site in, Wamsutter, Wyoming, US.

BP and unconventional gas

Natural gas, including gas from unconventional reservoirs, has an increasingly important role in meeting the world's growing energy needs.

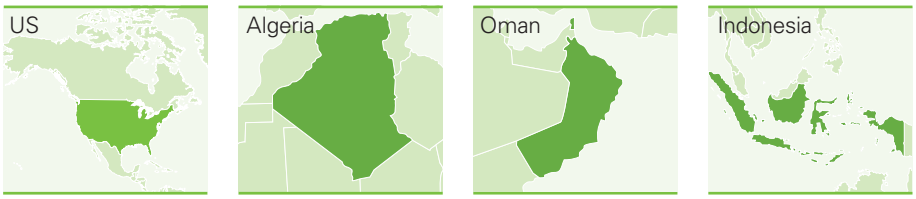
BP is working to responsibly develop and produce natural gas from unconventional resources including shale gas, 'tight' gas and coal bed methane – at our operations in the US, Algeria, Indonesia and Oman. More than 80% of our onshore natural gas production is from unconventional resources.

We believe these resources have the potential to contribute safely, sustainably and affordably to global energy security and efforts to reduce the emissions of greenhouse gases from energy use.

By our estimates, natural gas is likely to meet around 26% of total global energy demand by 2030. By then, it is projected that over half of US natural gas will come from unconventional sources.

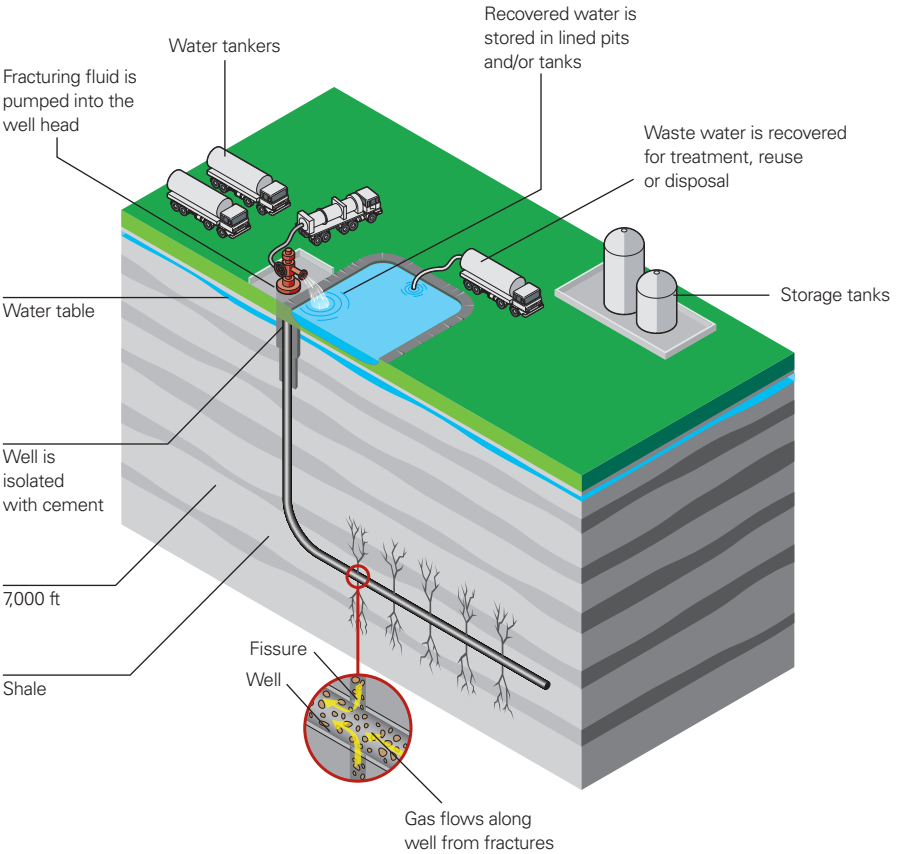
What is unconventional gas?

Conventional natural gas comes from permeable reservoirs, typically composed of sandstone or limestone, where extraction is relatively straightforward because the gas generally flows freely. In contrast, unconventional gas is situated in rocks with extremely low permeability, which makes extracting it much more difficult. New technologies and enhanced applications of existing techniques are making it possible for BP to extract these unconventional natural gas resources safely, responsibly and economically. The combination of horizontal wells, for example, and hydraulic fracturing have been key to unlocking unconventional gas reserves in the US and elsewhere.



BP has unconventional gas operations in four global locations.

Hydraulic fracturing process



What is hydraulic fracturing?

Hydraulic fracturing (sometimes referred to as 'fracking') is the process of pumping water, mixed with a small proportion of sand and chemicals, underground at a high enough pressure to split and keep open the rock and release natural gas that would otherwise not be accessible. This process has been applied since the late 1940s when Amoco, now part of BP, performed some of the first fracture treatments in the Hugoton field in Kansas.

The fracturing operation results in a significant increase in the surface area exposed within the formation – from 1,000 to 100,000 times more. This means it is possible to produce natural gas reserves that could not otherwise have been reached.

Stakeholder concerns

Some stakeholders have raised concerns about the potential environmental and community impacts of hydraulic fracturing during unconventional gas development. BP recognizes these concerns and seeks to apply responsible well design and construction, surface operation and fluid handling practices to mitigate these risks. We also believe that it is important to explain our plans to local communities, listen to their concerns and answer their questions.

Well publicized media and community concerns about unconventional gas production in the US have led to close regulatory scrutiny and a similar situation is emerging in the European Union.

BP is advocating for regulations based on the best-available science and sound technical practices. We believe hydraulic fracturing can be done safely and responsibly and that these techniques are important for the development of secure energy sources.

Managing water and other fluids

Hydraulic fracturing uses water and other fluids, which need to be sourced, managed and disposed of appropriately.

Can natural gas and drilling fluids enter underground water sources due to the fracturing process?

No – not if the well has been properly engineered and constructed. BP wells and facilities are designed, constructed, operated and decommissioned to mitigate the risk that natural gas and hydraulic fracturing fluids enter underground aquifers, including drinking water sources. For example, we install multiple layers of steel into the natural gas well and cement these above and below any freshwater aquifers.

We test the integrity of our wellbores (the hole that is drilled to form the well) before beginning the fracturing process and again when work at the well reaches completion. We monitor the integrity of the well throughout its production life. In the US, we conduct baseline water quality testing of nearby registered drinking water wells before drilling starts and share the results of these tests with local landowners.

In 2011, researchers at the Massachusetts Institute of Technology (MIT) examined 43 widely-reported onshore gas well drilling incidents in the mainland US between 2005 and 2009. They found no conclusive evidence that shallow water zones had been contaminated with hydraulic fracturing fluids during any of these incidents.[1]

Naturally occurring methane, a greenhouse gas, is often found close to the surface and within aquifers. To minimize the risk of methane interacting with underground drinking sources, we conduct geological studies of our natural gas production sites prior to drilling.

> "The shale gas production subcommittee shares the prevailing view that the risk of fracturing fluid leakage into drinking water sources through fractures made in deep shale reservoirs is remote."
>
> US Department of Energy Secretary of Energy Advisory Board, Ninety Day Report (August 2011)

Pumping water at one of our hydraulic fracturing operations. The business operates more than 10,000 producing gas wells across seven US states.

Doesn't fracturing use a lot of water?

Several million gallons of water are needed to drill and fracture some types of unconventional gas wells. This has led to concerns being raised about the water extraction, transportation and usage, particularly in areas experiencing water shortage.

We are trialling a number of water-saving innovations to minimize the amount of fresh water used in our drilling and hydraulic fracturing operations, including new technologies that could make it possible for us to treat water used in fracturing for re-use in our operations. We are also supporting research and development with universities, such as Texas A&M and the MIT, to identify and test new technologies that can be applied for water treatment purposes.

We think it is important to consider water usage across the entire lifecycle of these resources from production through to converting the resources into energy. Natural gas-fired power plants use significantly less water per unit of energy produced when compared with coal plants. For example, a report by the US Department of Energy found that natural gas-fired combined-cycle gas turbines use about half as much water as coal-fired plants. MIT also found that the water intensity of shale gas ranks among the lowest of all fuel sources.

Are the chemicals used in the fracturing process hazardous?

Water and sand constitute on average 99.5% of the injection fluid. This is mixed with chemicals to create the fracturing fluid that is pumped underground at high pressure to fracture the rock with the sand propping the fractures open.

The chemicals used in this process help to reduce friction and control bacterial growth in the well. They are mixed in a variety of ways depending on the operational needs of each fracturing operation. Some of the chemicals are classified as hazardous materials, as are the constituents of many everyday products when in concentrated form. Each chemical used in the fracturing process is listed in the material safety data sheets at each site, which detail safe dosage limits.

We take part in a number of voluntary disclosure efforts and we make public information about chemicals used to the extent allowed by our suppliers, who own the chemical formulas. For example, we submit data on chemicals used at our hydraulically fractured wells in the US at FracFocus.org.

1 *US Department of Energy, 'Energy Demands on Water Resources' (2006)*

Where does the water and hydraulic fracturing fluid used in the fracturing process go?

The main method of handling water that flows back from the well is to re-inject it into underground formations that are thousands of feet beneath and isolated from drinking water aquifers.

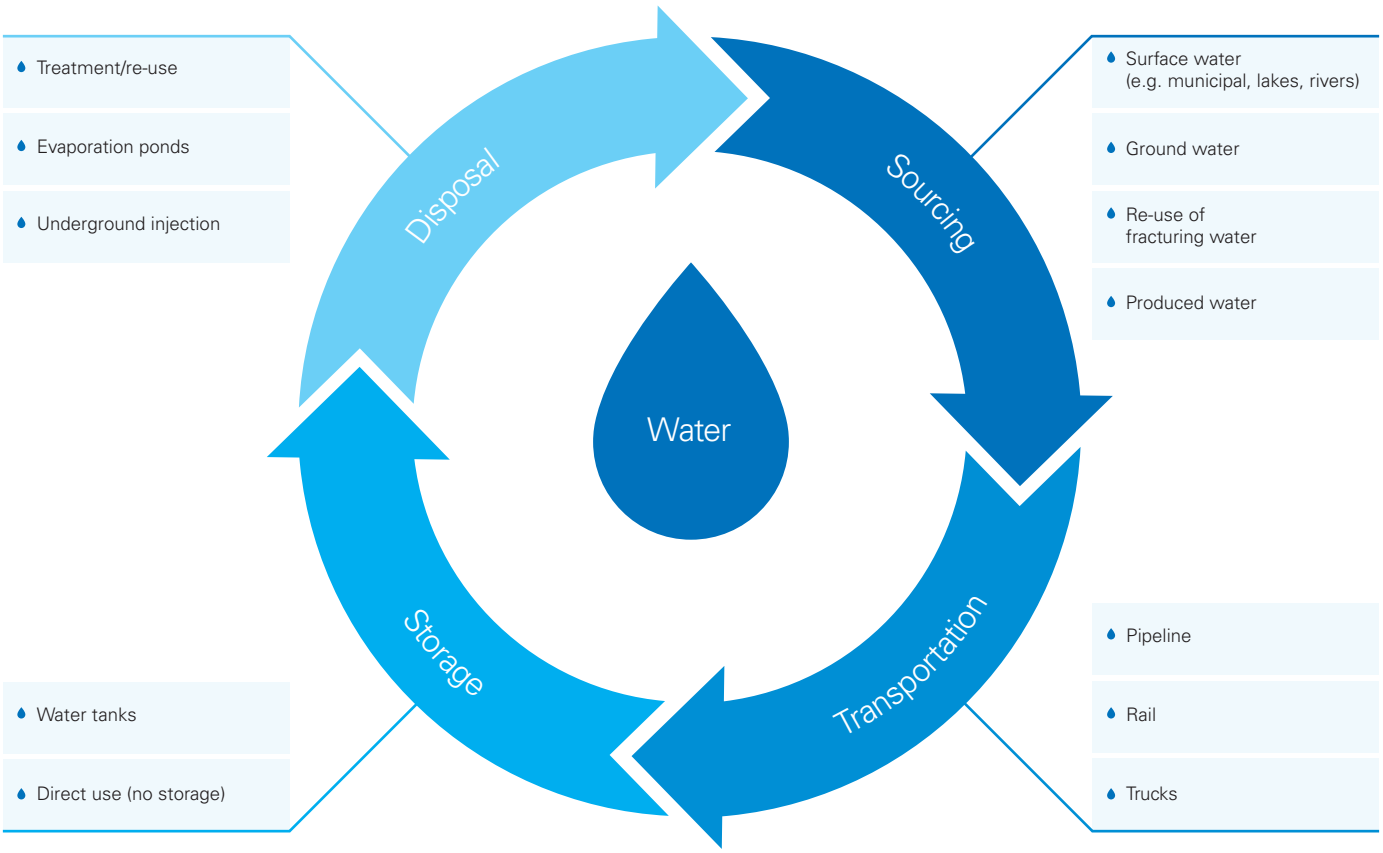
When underground re-injection is not viable, we explore other options including treatment of the water to regulatory standards. BP is also researching water treatment technologies to improve the opportunities for reuse within our operations. In cases where re-injection or treatment is not feasible, we use evaporation ponds to allow the water to naturally evaporate. BP puts impermeable clay or heavy duty polyethylene liners into our ponds to contain the liquid and prevent it from seeping into the soil.

In the US, we are developing a water management model to help determine the most economically and environmentally efficient means of managing water in our unconventional gas projects and operations. The model, covering areas such as how water is sourced and how it is transported, treated and disposed, is scheduled to be field tested in 2013.

BP's gas well site in Durango, Colorado, US, where we've operated for 30 years.

Water management model

Looking across the water lifecycle



Air quality and greenhouse gas emissions

New studies can help inform our management of air quality and the greenhouse gas footprint of natural gas operations.

What about the air pollution and greenhouse gas emissions associated with unconventional gas development?

Air emissions during drilling and hydraulic fracturing operations are mostly from the engines powering the equipment and are similar to those emitted by highway trucks.

These emissions occur for the relatively short time required to drill and fracture a well. Greenhouse gas emissions during these operations are mostly carbon dioxide emissions from fuel combustion.

During completion of a well, emissions can occur during the flow-back following hydraulic fracture and may include vented gases and pollutants from flaring which are similar to those from the normal use of gas as a fuel. Emissions during production include both vented and fugitive hydrocarbon gas, and the normal pollutants from use of natural gas as a fuel. Greenhouse gas emissions during these phases include both methane and carbon dioxide.

We aim to minimize air pollutant and greenhouse gas emissions by using responsible practices and controls at our operating sites.

How do you do this?

Where feasible, we seek to use:

- Natural gas or electricity instead of more carbon-intensive conventional fuel sources to power operations at sites where these energy sources are readily available and affordable.
- 'Green completion' techniques which recover natural gas as a product, to minimize the amount of natural gas either flared or vented from our wells.
- Infrared cameras to help us to locate and fix operational leaks more quickly and reduce emissions from fugitive leaks.
- Lower-sulphur fuels where available for the engines of our drilling rigs and hydraulic stimulation equipment which reduces sulphur dioxide emissions.
- Pipelines to reduce emissions from transportation by reducing the need for truck transport.

We also reduce transportation emissions by automating some operations (meaning that fewer site visits are required) and by transporting chemicals in dry rather than liquid form, taking up less space on trucks.

We are working with regulators and our industry to reduce emissions. For example, BP is a charter partner in the US Environmental Protection Agency's (EPA) Natural Gas Star programme, a voluntary initiative focused on practices to reduce methane emissions and we actively support the EPA's Global Methane Initiative. We are sponsors of and active participants in the World Bank's Global Gas Flaring Partnership which seeks to reduce flaring globally. We continue to evaluate the lessons being learned from these programmes to see whether we can apply them to our operations globally.

Above image: BP's drilling operation in Wamsutter, Wyoming, US.

Is natural gas as 'climate friendly' as publicized?

Questions have been raised about the greenhouse gas emissions associated with the lifecycle of natural gas development, particularly methane emissions during production and transportation to market.

We believe that methane emissions from natural gas development, particularly from production, are overestimated by some US studies. We have inventoried and managed methane and hydrocarbon emissions from our US onshore natural gas operations for more than a decade. Methane emissions from our operated US onshore natural gas assets are about a third of the level estimated by the US EPA for methane emissions from the US onshore natural gas production segment. We believe that onshore unconventional oil and gas resources can be developed with greenhouse gas footprints equivalent to other types of oil and gas development.

Natural gas has the lowest greenhouse gas emissions of any fossil fuel when burnt. When used for power generation, gas produces about 50-60% less greenhouse gas emissions than coal per unit of electricity generated. The substitution of coal-fired power generation with gas is a readily available and cost-effective option for reducing greenhouse gas emissions per unit of energy produced.

To continue to gain a better understanding of the greenhouse gas footprint of natural gas development, BP is working with other companies and trade organizations, the US EPA, and others to gather data and measurements to more accurately estimate emissions from the natural gas value chain.

Does hydraulic fracturing cause earth tremors?

Before conducting work, BP assesses the potential risks of induced seismicity (including minor earthquakes and tremors caused by human activity) resulting from our operations – for example, by identifying natural faults in the local area. This analysis informs our development plans for drilling and hydraulic fracturing activity.

Hydraulic fracturing creates microseismic events, but the magnitude of these is generally too small to be detected at the surface according to the *Assessing the environmental risks from shale gas development* study by the Worldwatch Institute. In rare cases when factors such as activating existing faults exist, hydraulic fracturing could induce seismicity equivalent to the vibrations of trucks.

We evaluate industry-recommended guidance for avoiding induced seismicity and we apply these practices to our operations as appropriate. We are working with others in the oil and gas industry to ensure that state-of-the-art knowledge and practices are put to use throughout our industry.

BP is a participant in an American Petroleum Institute interest group which is examining the perceived risks of induced seismicity and is developing educational tools to inform regulators and the public on this subject.

Pump trucks at BP's fracturing operations, Khazzan-Makarem field, Oman.

Managing community impacts

We consider the potential impacts of our operations on the local environment, society and economy.

How can unconventional gas extraction impact the local community?

Most oil and gas development in the past 50 years has occurred in rural areas or in areas with a history of oil and gas production. The recent development of unconventional resources has moved energy companies into new and often more populated areas.

Increased traffic, noise, dust, light and air pollution, visual impacts, disruption of wildlife and habitat, and increased pressure on the local infrastructure are some of the potential impacts. These impacts can vary depending on the stage of the operation. For example, the hydraulic fracturing stage, which typically lasts two to three months, is when drilling takes place and water and equipment are delivered to the site. The production phase, which may last several decades, has minimal surface impact.

How do we manage these impacts?

We manage these impacts in several ways. In the early stages of our projects, we assess the potential impacts of our operations on the local communities. We engage with those communities throughout the lifecycle of our operations. We provide information about our activities to the public, and we identify and respond to concerns and consequences. We also maximize our local hiring and provide workforce training about maintaining a positive relationship with local communities. We seek to design and locate our equipment and manage our work patterns in ways that reduce impact to relevant communities.

We believe that people living near oil and gas operations – and the general public – have information about our activities and we commit to Good Neighbor Pledges, such as the one created by the La Plata County Energy Council in the San Juan Basin.

Wherever we work, we strive to be the local energy company; training and employing local staff and contributing to the local community. For example, we donated $4 million to the San Juan College School of Energy in Farmington, New Mexico, in 2012 to help build a new facility for students pursuing careers in energy-related fields.

The investment is designed to help meet the growing workforce development needs of the US energy industry, at a regional and national level.

One way we engage with our local community is through community advisory panels. For example, the Durango Citizen Advisory Panel, in the La Plata County in Colorado, meets every month to discuss issues of interest to the local community and BP.

Through the panel, residents can voice their concerns and based upon their input, BP provides responses and looks for solutions. Recent topics have included royalties, an overview of local air quality management and how federal regulatory developments will be implemented.

Above image: Pronghorn antelope at BP's Wamsutter operations, Wyoming, US.

Right image:
Non-Executive Director Paul Anderson (second from left), who is also Chairman of the safety, ethics and environment assurance committee, and BP Chairman Carl-Henric Svanberg (second from right) on a board visit to BP's North America Gas operations in East Texas, US.

What about the noise from the drilling and the traffic from the trucks?

Drilling and truck traffic can raise concerns over noise and disturbance to the local community. BP designs facilities and plans road, pipeline and well pad locations to limit disturbances and mitigate noise and other impacts from drilling and truck traffic. To reduce the impacts from traffic, we seek to apply dust suppression techniques, install pipelines to transfer water in places where that is practical, and aim to minimize the number of kilometres driven.

Is it safe to work at a hydraulic fracturing site?

We have issued guidance throughout BP on how to drill and maintain wells to high, consistent standards. We assess health hazards, such as noise, chemical and silica dust exposure. We also implement hearing and respiratory protections for our workforce where this is needed. Designated BP representatives at every well site help make sure that the work done by our contractors conforms with BP and regulatory requirements.

We take road safety very seriously. Our drivers are required to undergo assessments and need to be trained, licensed and medically fit to operate a vehicle. We limit the number of hours they can work, and in some circumstances we perform pre-trip risk assessments and develop journey management plans to minimize any exposure to potential hazards.

We helped pioneer the US National South Texas Exploration and Production Safety Network, which brings together operators and contractors to promote safety, health and environmental improvement in US onshore oil and gas operations. We are working to apply the lessons learned from this programme in our exploration and production operations globally.

What happens to the animals and plants that live close to the operations?

Hydraulic fracturing operations disturb the land and can impact sensitive ecologies. We design our operations with the aim of avoiding potential impacts. For example, we identify and attempt to avoid impacts to sensitive species, habitats and archaeology. If such impacts are unavoidable, we seek to minimize them. When this is not a viable option, we explore means of compensation.

To minimize land use and reduce the number of well pads, we use techniques such as placing multiple wells on a single well site. We also use construction practices that minimize the physical footprint of the operations, and we carry out field studies in areas such as planting techniques and topsoil storage and reuse to help us restore the land after construction.

Reports and publications

This report is part of BP's corporate reporting suite. We also report on our sustainability performance, and our financial and operating performance.

Sustainability Review
Read the summary *Sustainability Review 2011* in print or read more online.
bp.com/sustainability

Summary Review
Read a summary of our financial and operating performance in *BP Summary Review 2011* in print or online.
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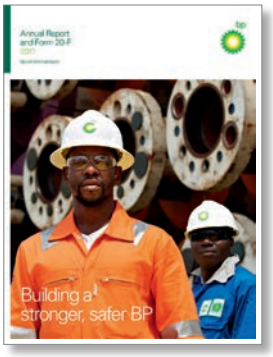
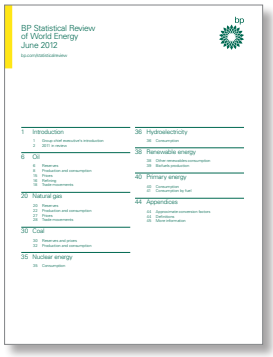


Annual Report and Form 20-F
Read details of our financial and operating performance in *BP Annual Report and Form 20-F 2011* in print or online.
bp.com/annualreport

Oil sands issue briefing
Read about BP's investment in Canadian oil sands.
bp.com/oilsands



Statistical Review of World Energy
The *BP Statistical Review of World Energy June 2012* reports on key global energy trends.
bp.com/statisticalreview

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