# Offshore Production, Storage and Transportation

number 3 of a series of papers on energy and the offshore Nov., 1998

## IN THIS ISSUE




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## WHAT ARE THE DIFFERENCES BETWEEN OFFSHORE EXPLORATION AND PRODUCTION?

Offshore production simply means all the activities needed to actually develop an oil or gas reserve. It is more extensive and lasts longer than exploration, and, unlike exploration, it usually means the installation of permanent platforms at the wellhead. Pipelines may be laid on the sea-bed, or tankers may shuttle back and forth, taking the hydrocarbons to shore.

This fact sheet talks about a number of aspects of the production phase of offshore hydrocarbon development. It builds on two others in the series, Hydrocarbon Resources and Offshore Exploration.

Going from exploration -to production is a major step in the development of any offshore reserve. Mostly the difference is one of size—an offshore development has many of the same activities as a single exploratory well, but on a larger scale and for a longer period.

Development includes putting in place offshore equipment, and drilling wells into the subsea reservoirs. This is the *construction phase*. The ongoing operation of the facility, while it is producing hydrocarbons for market, is the *production phase*. In contrast to a single exploratory well for which drilling can last as little as three months, drilling of the many wells which make up a project can last many months and produce many times the wastes.

During construction, permanent structures are put in place inside the well, and *production platforms* are installed on the sea-bed, to support the equipment needed to bring the oil and gas to the surface. Once in place, sea-bed platforms and other production equipment can remain from five years to a quarter of a century or more.

The actual drilling of the well may take place earlier, later, or at the same time as placing the platforms. Much the same drilling equipment is used as for

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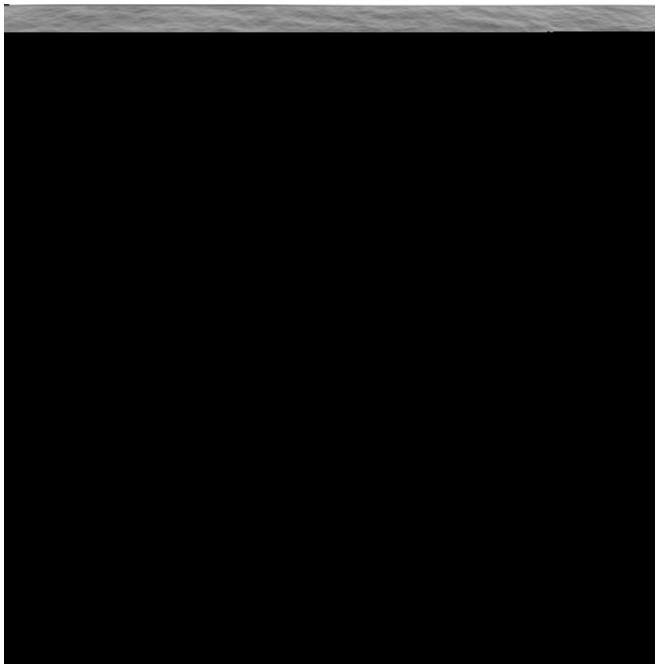


***jack-up rig at the Cohassset Project***

# What do you find at an offshore production well?

Production facilities are the wells drilled to yield oil and gas, and all their equipment. Production drilling and procedures are designed to best remove the hydrocarbons from their surrounding rock. Production equipment takes the raw gas and liquids and processes them to remove impurities, before transferring them to pipelines and/or tankers for shipment.

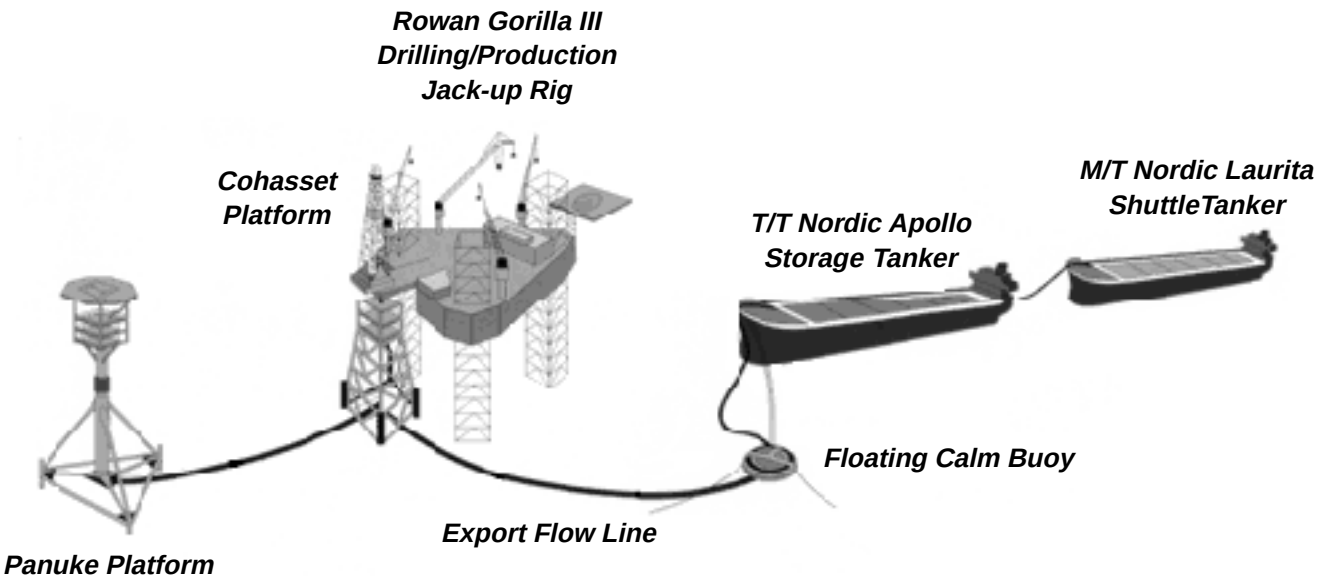
One or more wells may be drilled to reach the rock layers containing hydrocarbons. The drilling approach and the number of wells is tailored to the particular site. Up to a half dozen or more individual wells may drilled close to each other so that they share a common production facility.

The pipes or casings which surround and protect the well at the sea-bed are referred to as the 'jacket'. Jackets are fixed to the sea-bed for the life of the project.

Production platforms are the combinations of jackets and associated equipment (topside facilities) to manage production. Many types of production platforms are found in the offshore, reflecting the specific needs of the field and hydrocarbon source.

Topside facilities have the equipment needed to process the liquid or gaseous hydrocarbons, as well as crew quarters, generators, cranes etc. They also may have specialized equipment at the sea-bed to connect to the system for collecting hydrocarbons, safety valves, and equipment to inject water into formations to increase the flow of hydrocarbons. As well, pipeline and cables may be installed to connect and control equipment at the various wells that may be developed in a particular field.

The platforms and jackets may also allow for the drilling of additional wells to further develop the field. An offshore project may have from one to several platforms and may have various combinations of types of platforms. Natural gas projects may also have a pipeline leading to shore, like the Sable Offshore Energy Project near Sable Island.




*The Cohasset Project*

# TWO CONSTRUCTION BASICS

### *Drilling*

Drilling production wells opens the reservoir, allowing the oil or gas to be brought to the surface. Current techniques allow precise control of the direction of drilling (*directional drilling*); in addition to the vertical, wells can be drilled at an angle, and even horizontally. As well, multiple *well bores* leaving the main bore at various angles can be made from a single wellhead. This allows many wells to be drilled from one site, and lets more of the hydrocarbons be recovered from the rock strata. Directional drilling techniques can shorten the time required to develop a field, and reduce the number of wells which must be drilled, consequently requiring fewer production platforms.

### *Geotechnical Surveys*

Companies carry out geotechnical surveys to gather information on the sea-bed, to help them design their production facilities. A typical geotechnical survey involves shallow drilling, about 100 m, to sample the types of materials in the sea bed, and how sediments are produced during drilling. This ensures that the structure can be stable and safe, and also identifies hazards such as gas deposits. Geotechnical drilling uses a smaller drill rig than the larger ones which conduct exploratory drilling. Geotechnical studies may also involve shallow seismic work to further examine the sediments beneath the surface.

## WHICH WAY TO MARKET?

There are two ways to get the hydrocarbons produced in an offshore well to market – pipelines or tankers. Tankers are normally used exclusively for liquid hydrocarbons such as crude oil and condensate. In some areas of the world where markets are suitable, gas may be liquefied (LNG) and transported by special tankers, but this is not a usual option for offshore operations. Pipelines can be used both for natural gas and liquid hydrocarbons.

Production facilities using tankers have flow lines which run along the sea floor where a mooring for a tanker

***Cohasset Project Tanker***

## HOW *DO* YOU GET OIL AND GAS OUT OF THE GROUND?

Usually, the natural pressure in the reservoir forces oil and gas to the surface. However as reservoirs of liquid hydrocarbons such as crude oil become depleted, drillers may inject water into the well below the level at which the hydrocarbons are found. Because oil is lighter than water, this pushes the oil up, and helps it flow to the surface. Natural gas reservoirs normally produce under their own pressure.

In drilling a production well, you can also change the rock in a reservoir to allow the hydrocarbons to enter the well more readily. For example, rocks may be put under high pressures, causing them to expand along fissures (*fracturing*) and increase the flow of hydrocarbons through these breaks.

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# Offshore Production Facilities: an overview of impacts

As in industries everywhere, offshore production means wastes and discharges. Some discharges take place only occasionally during the life of the production platform, while others are more or less routine.

What kinds of discharges and acceptable levels are controlled by agencies such as the Canada Nova Scotia Offshore Petroleum Board (CNSOPB), an independent agency responsible for overseeing development the offshore. A company cannot hold an operating permit unless it complies with a range of regulations (more information on how the offshore is regulated is explained in the companion fact sheet "Offshore Regulations").

## Occasional Discharges

### Drilling mud, cuttings and associated chemicals

Drilling mud, cuttings and associated chemicals are normally released only during the drilling phase at the beginning of the project, and occasionally thereafter if new wells have to be drilled or if wells require maintenance. These discharges are the main environmental concern in offshore development and their use is tightly regulated.

*Rowan Gorilla III*

Drilling muds are slurries of clays and powered heavy minerals as weighting agents, as well as various additives. Some muds are released in large batches, while others are released as residual amounts adhering to the rock chips (cuttings) remaining after sieving them from the drilling fluids. The discharges are closely monitored by the offshore operator and releases are controlled as a condition of the operating permit.

One type of mud known as water-based mud (WBM) is a mixture of water, bentonite clay, and chemical additives, and is used to drill shallow parts of wells. It is not particularly toxic to marine organisms and disperses readily. Under current regulations, it can be dumped directly overboard.

Companies typically recycle water-based drilling muds until their properties are no longer suitable, and then dump the entire batch overboard over a period of hours. These types of muds are relatively non-toxic to marine organisms (including scallops).

For drilling deeper wells and when problems such as pipe sticking occur, oil-based muds (OBS) are normally used. The typical difference from water-based muds is the high content of mineral oil (typically 30%). OBMs also contain barite, a powdered heavy mineral, and a number of additives. OBMs have a greater potential for environmental impacts, partly because they tend to stick together and may not disperse as readily. They contain greater concentrations of barite which may impact some organisms, particularly scallops; and the mineral oil may have toxic effects. Release of OBMs

## LOCAL SUPPLIERS

Typically, offshore production facilities need services which can be supplied at nearby ports by local communities. Such things as repair and maintenance of supply vessels, metal fabrication, ships' chandlers, and stevedoring in support of offshore production facilities will take place in ports nearest to the offshore operations. An innovative local economic effort connected to SOEP is the Bayview Marine Services Co-operative, formed by a number of local fishermen and boat owners. They are supplying services to SOEP activities like the Nearshore Monitoring Program, ranging from towing zooplankton collection nets to lobster trapping to providing boats for shipwreck surveys!

Onshore facilities, such as natural gas plants, often employ staff who live in the area and contribute to the its economy; as well as directly providing jobs, many needed services can be supplied locally.

are more tightly controlled. Currently only the residues of OBMs adhering to rock cuttings may be released overboard, and then only mixtures up to a specified maximum oil content.

During drilling, techniques are used to reduce the oil content in cuttings to levels specified in the operating permit, and also to separate

***oil-based muds will not be permitted on Georges Bank should the moratorium be lifted.***

oil from the water it contacts. Otherwise, used OBMs from offshore operations must be shipped to shore for disposal.

The CNSOPB has already announced that after December 31, 1999, the oil content in cuttings will be limited to 1% by weight, which virtually eliminates the releases of oil-based mud and cuttings in the offshore. The 1% tolerance allows for small amounts of oil taken into water-based muds in unusual circumstances, e.g., to free a stuck drill pipe.

#### *Well treatment*

A variety of chemicals and substances may be used in periodic "conditioning" of rock formations to improve production from a well. Sometimes these are released into the environment, usually as a component of a discharge such as drilling mud.

## *Routine discharges*

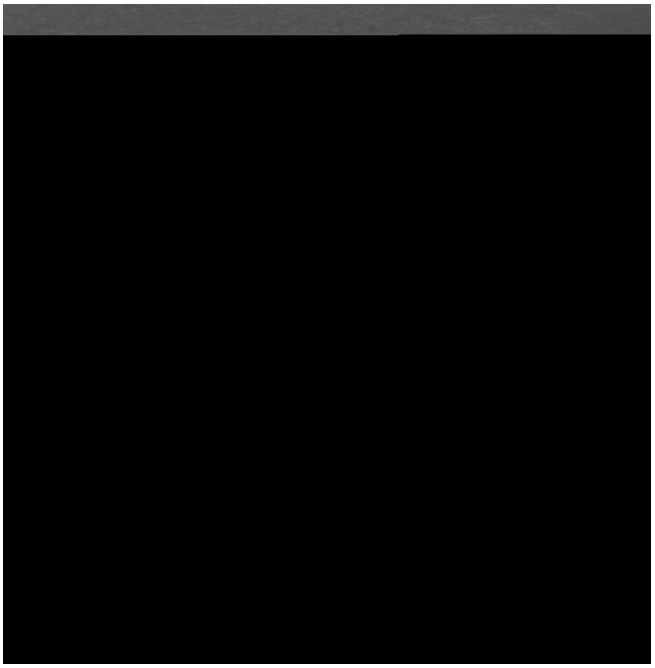
#### *Produced water*

Saltwater or "formation water" that is found with the hydrocarbons in the well, as well as water injected into rock formations to increase their flow, is usually released as a stream from the well; this is known "produced" water. It is passed through separators to reduce its hydrocarbon content to specific regulated levels. Nonetheless, the continual discharge of produced water and the associated low levels of oil can lead to long-term contamination in some cases. The amounts released may vary from as little as 16 cubic metres per day to as much as 17,000 cubic metres per day. The rate of produced water released typically increases as the well progresses to the end of its useful life. Produced water may also have elevated concentrations of contaminants such as metals, and in some areas has low levels of radioactivity from the rocks in which it was trapped.

#### *Deck Wash*

Working areas on production platforms are washed and exposed to rain, snow and spray, creating wastewater. This may have a range of contaminants picked up incidentally on both production platforms and supply ships.

Much of the deck wash from platforms is collected and treated to remove oils before discharge over the side.



***Panuke platform, Cohasset Project***

#### *Domestic Wastewater and Sewage*

The daily needs of domestic life on board the platform, like food preparation, showers, and laundry all produce wastewater; it, as well as sewage, are also typically discharged into the marine environment. Domestic sewage may be disinfected before release, but the use of chlorine carries its own set of environmental concerns.

#### *Produced Sand*

Up to several barrels annually of bits of rock and sand from rock formations are found in the gas and other hydrocarbons leaving offshore wells; this is known as produced sand, and is usually dumped overboard.

## *Accidental Discharges*

Supplies and materials may be spilled accidentally on the platform or during transfer from supply vessels.

#### *Structural Maintenance*

Offshore production platforms, like seagoing vessels, develop growths of seaweed, bacterial slime and animals such as barnacles; this is known as fouling , and must be removed by regular cleaning. The remains enter the sea. Cleaning and repainting and other maintenance may result in paint residues being released to the marine environment; in particular, "anti-fouling" paints have additives which may kill marine life. Paint types must be chosen carefully to limit these chemicals.

#### *Blowouts and spills*

Blowouts and spills are a risk, albeit an unlikely one, of offshore hydrocarbon production. No two spills or blowouts are exactly the same, but it is possible to

***continued on next page***

*Impact Overview (from page 5)*

make some general statements. The two types of hydrocarbons likely to be found in drilling on Georges Bank, natural gas and condensate, can have comparatively minor spill impacts. Natural gas released in a blowout is mostly dispersed in the air by winds. Condensate evaporates quickly (like gasoline) and leaves negligible residues either released as a blowout or a spill on the sea surface. In general these are less likely to cause serious harm to species such as birds, than spills of heavy oils such as crude.

## Effects on fisheries

The most significant effect of routine offshore production on fisheries comes from keeping fishing boats out of the safety zone around the platform & pipelines. This area is typically 500 meters from the platform or 50 meters outside the anchors, whichever is greater. This is usually only a small part of the fishing grounds, and studies from other parts of the world have shown that local finfish and aquaculture fisheries have typically not been impacted. However, sea scallop, the most important single fishery on Georges, may have a potential to be impacted under certain conditions; effects on this species are currently under intensive study.

### Tainting

Tainting is an off-taste or flavour in a product that a consumer can detect. It is highly undesirable because it can greatly harm the marketability of a product – no one wants to eat seafood that tastes wrong, and word can spread rapidly among brokers and consumers if tainted products appear.

Research in fisheries near oil production sites in other oil fields have shown that taint has not been observed in finfish in these areas. However, scallop and other suspension feeders in the vicinity of a platform may have the potential to accumulate taint. This could occur from coming into contact with hydrocarbons and other compounds in the drilling mud discharges. Taint might also result from prolonged exposure to produced water, which contains low levels of both hydrocarbons and trace metals.

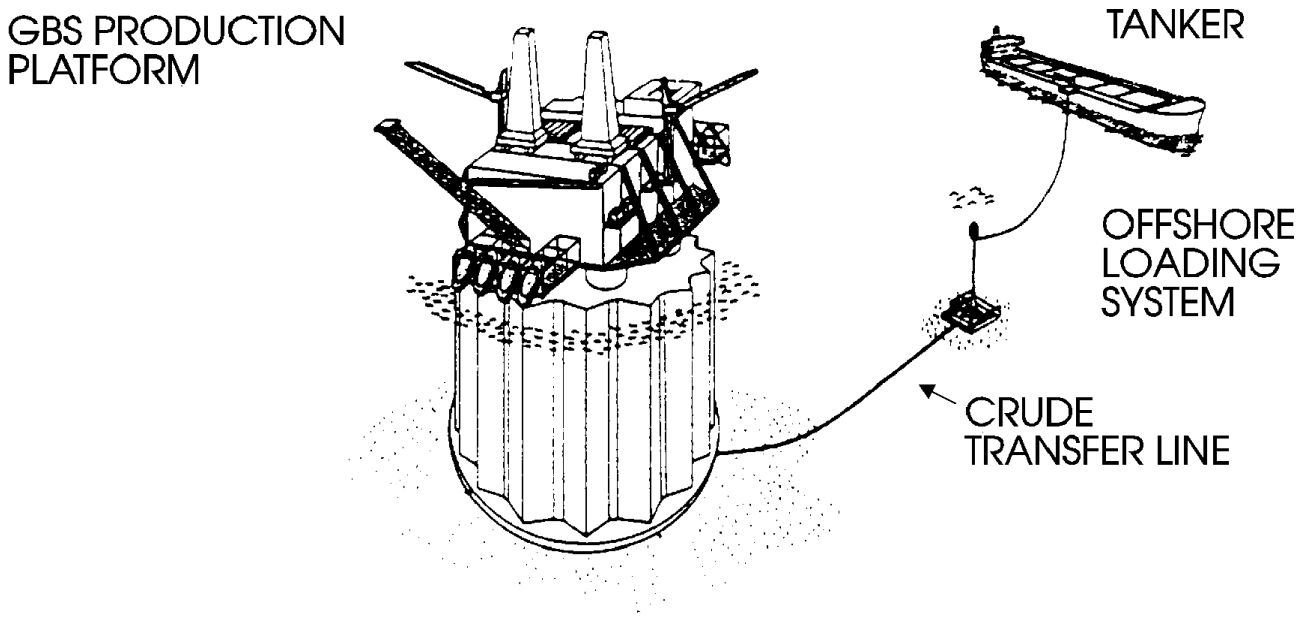
## Some Benefits

Offshore oil and gas facilities can have positive impacts. For example marine growth on the rigs can attract and harbour fish and other organisms, while discharges may create a local 'hot spot' of biological productivity.

Rigs and support vessels in the offshore provide access for sailors to communications and help, both under normal operations and in emergency. Rigs are visible on radar and provide little threat to fishing vessels.

Infrastructure improvements which have spin-off benefits for the community can happen because of the need for wharves, roads, and other coastal facilities.

# TRANSHIPMENT AT HIBERNIA



## Exploration and Production (from page 1)

exploration wells, but drilling production wells uses specialized techniques and involves more wells than for the exploration stage. Wells are drilled to reach specific target rock layers, and more wells are drilled so that the flows which are produced are economic. Production drilling can also include techniques to sink holes at an angle, so that reservoirs over a wide area can be reached from a single offshore site.

After drilling, the wells receive special treatments to improve flow rate and yield, and are equipped with piping and fittings to bring the hydrocarbons to the surface and connect with equipment on the production platform.

Different rules and regulations are placed on offshore activity depending on whether it takes place in the exploratory or development phases. In Canada, when a project proceeds to the development stage, it has the potential to be subjected to a formal environmental assessment, in which all aspects of the project are examined closely to determine if they are likely to have a harmful effect on the environment or the community, and to determine whether potential impacts are understood, how severe they might be, and if they can be controlled.

***Transshipment at the Cohasset Project***

## Getting to Market (from page 3)

is installed at a safe distance from the wells. In some cases, one tanker may be kept more or less permanently at the site to fill up or store liquid hydrocarbons. The hydrocarbons can be transferred rapidly to other tankers arriving on site for shipment. This type of arrangement is currently used on the East Coast at the Cohasset Project, operated by Pan Canadian Resources Limited west of Sable Island. The project has a pair of wellhead platforms, flow lines connecting them, and a line from the production platforms to a moored tanker to store the condensate. A jack-up rig, *Rowan Gorilla III*, anchored beside one of the platforms, serves as the production platform.

At the Hibernia development on the Grand Banks of Newfoundland, the production platform houses both drill rigs and internal oil storage tanks. Crude oil from this project is pumped through a short sea-bed pipeline to a mooring and then onto tankers which visit regularly.

Different again is the Sable Offshore Energy Project (SOEP), expected to be producing in late 1999. The project has several wellheads, with one main platform complex, Thebaud, south of Sable Island. The Thebaud facility will collect gas and condensate from all the wellheads, treat them to remove impurities such as water and sand, compress the gas, and transport them both through a pipeline to shore at Goldboro, Nova Scotia.

Small pipelines 30 to 45 cm in diameter and associated cables and flowlines will run from the main platform to service the wellheads. A larger pipeline of 61 cm diameter will run the 225 kilometres to shore. A gas processing facility (gas plant) is being built on shore at Goldboro to receive the natural gas and condensate further treat them to remove any lingering impurities. The natural gas will then flow into the main underground pipelines which will run through Nova Scotia and New Brunswick to New England. The condensate produced from the wells will be shipped by underground pipeline from the gas plant to a storage and refining facility in Port Hawkesbury on the Strait of Canso.

## WHAT HAPPENS WHEN A WELL IS ABANDONED?

When the useful life of a production platform is reached, the equipment is removed. The well casing is severed and closed below the sea-bed to eliminate hazards to trawling. Sea-bed pipelines are typically left in place; they are not normally considered a hazard to bottom trawling and dragging, as gear can ride over top them. However, provisions can be made for their removal as well.

## What is in a typical light oil?

| (Molecular size (number of carbons) and % by volume) | |
|---|---|
| Gasoline (C5 to C10) | 27% |
| Kerosene (C11 to C13) | 13% |
| Diesel Fuel (C14 to C18) | 12% |
| Heavy Gas Oil (C19 to C25) | 10% |
| Lubricating Oil (C26 to C40) | 20% |
| Residual Hydrocarbons (more than C40) | 18% |
| Total: | 100% |

# Offshore Production, Storage and Transportation

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## GLOSSARY

Condensate – a natural gas liquid produced from a deep well where temperature and pressure are high. Gas condenses as it rises up the well bore and reaches the surface as condensate. It also separates out naturally in pipelines or in a separation plant.

Crude oil – a liquid mixture of many substances, mostly hydrocarbons.

Liquified natural gas – LNG is natural gas which has been liquefied for transportation by chilling it until it is extremely cold. Natural gas occupies 635 times the volume of LNG before it is liquefied.

Raw natural gas – natural gas with water and other unwanted substances and impurities, such as nitrogen. These are removed before the gas is sold.

Sour gas – an acid natural gas with a significant amount of hydrogen sulphide (the same chemical that makes rotten eggs smell so bad); in Canada, commonly found in the west, e.g. in the Alberta gas fields.

Sweet gas – natural gas containing only very small amounts of hydrogen sulphide gas and carbon dioxide. Sweet gas contributes less to acid rain and corrosion. Most Scotian Shelf and North Sea gas is naturally sweet.