Fundamentals

Unconventional Oil & Gas | Fundamentals

[ww-shortcode-divider style="thin"]In oil and gas industry, the term "**Unconventional**" refers to hydrocarbon resources that are or could be exploited with processes and techniques of drilling and production other than those commonly used by the upstream industry all over the world..

The term unconventional has been subject to different definitions, and various agencies or industry companies may have developed their own definition.

The Society of Petroleum Engineers (SPE), for instance, defines "Unconventional Resources" as petroleum accumulations that are prevalent throughout a large area and that are not significantly affected by pressure exerted by water (hydrodynamic influences); they are also called "continuous-type deposits" or "tight formations."

An energy industry firm – Schlumberger – uses the term "Unconventional" referring to oil and gas reservoirs whose porosity, permeability, fluid trapping mechanism, or other characteristics differ from conventional sandstone and carbonate reservoirs.

Another energy industry company, IHS, defines "Unconventional" as a term which refers to hydrocarbon resources that cannot be produced at economic flow rates or that do not produce economic volumes without particular activities and operations such as stimulation, special recovery processes and advanced technologies.

The existence of unconventional resources has been known for many years, but, it is in the last decade that, a combination of economic and geopolitical factors, together with advances in directional drilling and well stimulation technologies, has made them commercially exploitable on a large scale.

In particular, the last two decades have seen an increase in the price of crude oil and natural gas, and this aspect has led companies to focus on developing hydrocarbon resources whose production would formerly have been judged to be uneconomic.

The emergence of unconventional oil & gas has had a great impact on the global energy system, and their development has been supported by several factors such as a favourable regulatory regime in some countries, the previously cited issue of high prices of conventional resources, the significant technological advancements in areas of horizontal drilling, of thermal EOR processes (TEOR), and of hydraulic fracturing (fundamental for their exploitation).

Resource Triangle (Master & Gray – 1979)

There are many different kind of hydrocarbon unconventional resources, among them it is useful to mention and briefly describe:

- **Shale oil and shale gas**
  - It is defined as the oil or natural gas that occurs in the fined-grained, organic-rich rocks which are their source rock
  - A part of the generated hydrocarbons, in fact, remains trapped within the source rocks itself with no or minimal migration
  - The reservoirs have very low porosity and permeability
  - Shale oil must not be confused with oil shale, which is a precursor of oil called kerogen, and constitutes the building blocks of conventional

    oil
  - More than half of the identified shale oil resources outside the United States are concentrated in four countries
    - Russia, China, Argentina, and Libya
  - More than half of the non-U.S. shale gas resources are concentrated in five countries
    - China, Argentina, Algeria, Canada, and Mexico.

Map of basins with assessed shale oil and shale gas formations, as May 2013

- **Tight Oil & Gas**
  - It is defined as the oil or natural gas that occurs in very low permeability reservoir rocks such as fine-grained sandstones, siltstones, silty shales and, to a much lesser degree, fine-grained carbonates and marls
  - Such reservoirs are either in the proximity or interbedded with the source rocks, carbonaceous shales interbedded with coals in a fluvial-deltaic systems, etc.
  - They typically have a total effective porosity less than 15% (can be higher or lower) and an absolute permeability ranging between 0.1 mD and 0.001 mD
  - The density and viscosity of the oil are considered as critical factors for the productivity of wells drilled in so low permeability environment – oils with stock tank density < 25° API are, in fact, too heavy and viscous to be produced.

- **Oil Sands**
  - They are naturally occurring porous rock layers consisting of a mixture of sand, clay, water, and a dense and extremely viscous crude oil referred

    to as Bitumen or Tar (when the lighter fractions of the oil have escaped, leaving a residual asphalt)
  - The crude oil from these sands typically has stock tank gravity less than 10° API (Extra Heavy Oil
  - Mining methods and in-situ recovery processes are used to extract the crude oil from the rock: the surface mining is applied for near-surface deposits, i.e. for depths < than 100 m, while the thermal processes such as SAGD, CSS, steamflooding, etc. are used for deeper depth
  - Bitumen and tar are very viscous, and have to be heated or diluted with some solvent to make them flow
  - The separation of oil from sand is done by using hot water and chemicals; the oil can be sold as raw bitumen or upgraded to a lighter crude
  - Oil sands can be found in several locations around the globe (Venezuela, Canada, United States and Russia). The canadian deposits in the Alberta province are considered the largest one all over the world; they are also the most exploited thanks to technologically advanced production processes.

Oil Sands Sample

- **Coalbed methane (CBM)**
  - CBM is typically methane gas trapped within coal deposits – natural gas in association with coal beds/seams
  - The methane is usually mixed with carbon dioxide, other hydrocarbons and nitrogen and this mixture of gases will be referred to as the Coal Gas
  - During the coalification process, large quantities of methane-rich gas are generated and stored within the coal on internal surfaces.
  - Because coal has such a large internal surface

area, it can store surprisingly large volumes of methane-rich gas (6-7 times as much gas as a conventional natural gas reservoir of equal rock volumeof rock)
- The gas generated is adsorbed onto micropore surfaces and stored in cleats, fractures and other openings in the coals
- Gas is held in place by water pressure and does not require a sealed trap as do conventional gas accumulations
- Much of the coal, and methane, can be found at shallow depths, making wells easy to drill and inexpensive to complete
- Exploration costs for coal-bed methane are low, and the wells are cost effective to drill

Typical CBM Production Curve (IEA)

Schematic section of CBM exploitation (IGas)

- **Natural Gas Hydrates**
  - They are solid compounds formed when water and certain gas molecules are brought together under suitable conditions of relatively high pressure and low temperature
  - They occur naturally and widely in sediments associated with deep permafrost in Arctic, and in continental margins at water depths generally greater than 500 meters at mid to low latitudes and greater than 150-200 meters at high latitudes – in such conditions they are rather stable or dissociate very slowly
  - They contain vast reserves of methane and other natural gases, which could be referred to as Hydrate Gas.
  - According to the United States Geological Survey, the world’s gas hydrates may contain more organic carbon than the world’s coal, oil, and other forms

of natural gas combined

- Estimates of the naturally occurring gas hydrate resources vary from 10,000 trillion cubic feet to more than 100,000 trillion cubic feet of natural gas.

Left – Natural gas hydrate burning

Right – The structure of methane hydrate. Molecules of methane are trapped within a ‘cage’ of water ice molecules

Hydrate Phase Diagram (Oilfield Review)

Map of global hydrate distribution

Red dots show locations where hydrate has been found on continental margins (Oilfield Review)

IHS CERA: Fueling the Future with Natural Gas – January 2014

Exxon Mobil Corporation: Unconventional Resources Development – Managing the Risks – 2014

UK Department of Energy and Climate Change: The Unconventional Hydrocarbon Resources Of Britain’s Onshore Basins – Shale Gas – 2013

IEA: Golden Rules for a Golden Age of Gas – 2012