UNCONVENTIONAL RESOURCES

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Unconventional Petroleum

Unconventional petroleum resources are classified from different perspectives based upon their attributes and characteristics and according to the reservoir rock type, oil and gas origin, source–reservoir–cap assemblage, and occurrence state

Unconventional resources are resources, generally oil or natural gas resources, that do not appear in traditional formations and must use specialized extraction or production techniques to obtain fuel from the deposit. For oil and gas, conventional deposits are porous and permeable rocks below ground that contain tiny connected pore spaces that contain oil or natural gas.

Table 2.5. Classification Schemes and Main Types of Unconventional Petroleum

Basis for Classification		Main Types
Type of reservoir		Tight sandstone oil/gas, shale oil/gas, CBM, Cate fracture–cavity oil/gas, volcanic reservoir oil/gas, metamorphic reservoir oil/gas
Maturity, density, and viscosity		Oil shale, heavy oil, oil sandstone, shale oil, tight oil, shale gas, coal-derived gas, tight gas
Host and coupling relationship		Liquid/solid coupled (tight oil and gas, shale oil and gas, coal-derived gas), gas/water/solid integrated (natural gas hydrates), gas/water infused (water soluble gas), hydrodynamic barrier (hydrodynamic seal gas)
Genesis of oil/gas	Maturity	Thermal-origin, biologic-origin, mixed-origin oil/gas
	Source of parent material	Organic-origin, inorganic-origin, mixed-origin oil/gas
Source–reservoir–caprock assemblage	Source–reservoir relationship	Source–reservoir integrated, source–reservoir contacted, source–reservoir separated
	Source–reservoir assemblage	Self-source, self-reservoir oil/gas (CBM, shale oil/gas); nonself-source, self-reservoir oil/gas (tight sandstone oil/gas)
	Source of oil/gas	Self-source oil/gas (CBM, shale oil/gas), nonself-source oil/gas (tight sandstone oil/gas)
Occurrence state of coalbed methane		Adsorbed, free, mixed
Continuous property		Continuous petroleum accumulation, quasi-continuous petroleum accumulation

Table 2.6. Types of Petroleum Resources

Resources Type	Distribution Characteristics	Type of Petroleum Accumulation	Model Diagram	Example
Conventional petroleum	Single	Structural reservoirs		Permian–Triassic North–South Pars gas field, Persian Basin; Cretaceous Daqing Changyuan oil field, Songliao Basin
	Cluster	Lithologic reservoirs		Cretaceous lithologic oil reservoir, Songliao Basin
		Stratigraphic reservoirs		Ciferous–Jurassic stratigraphic oil reservoir, Northwestern Junggar Basin
Unconventional oil and gas	Quasi-continuous	Cate fracture–cavity hydrocarbons		Cambrian–Ordovician fracture–cavity oil/gas in platform basin, Tarim Basin
		Volcanic reservoirs and hydrocarbon accumulations		Ciferous–Permian Kelameili gas field, Niudong oilfield, North Xinjiang
		Metamorphic reservoirs and hydrocarbon accumulations		Xinglongtai internal paleo-buried hill oil/gas, Liaohe Sag
		Heavy oil		Neogene heavy oil, Bohaiwan Basin

Unconventional oil and gas	Quasi-continuous	Oil sandstone oil	Jurassic oil sandstone, Northwestern Junggar Basin
		Natural gas hydrate	Hydrate in slope region, north of South China Sea
	Continuous	Tight sandstone oil and gas	Ciferous–Permian, Triassic tight oil/gas, Ordos Basin
		Tight Cate oil/gas	Eagle Ford tight oil, North America
		Shale oil and gas	Triassic shale oil, Ordos Basin; Cambrian, Silurian shale gas, Sichuan Basin
		Coalbed methane	Ciferous–Permian coal-measure gas, Qinshui Basin
		Shale oil	Cretaceous oil shale, Songliao Basin

Unconventional Oil

Unconventional oil is a very specific type of petroleum obtained by methods that are different from the extraction technique of using a traditional well.

This type of oil is seen as being more costly and difficult to extract and refine, as well as being more environmentally harmful.

In general, unconventional oil is heavier and requires more processing and upgrading. Unconventional oil includes shale oil, oil sands and extra-heavy oil (natural bitumen deposits).

In total, only about 3% of 2009's oil production came from unconventional oil sources. Although it is more difficult and costly to extract unconventional oil, it is becoming more common as the demand for oil is increasing and more research is being done to see how unconventional oil can be made more simple and cost-effective to produce.

Shale oil

Shale oil, also called **tight oil**, is a type of oil that can be extracted by heating and upgrading kerogen trapped within shale formations - arrangements of fine-grained sedimentary rock.

Shale that oil can be extracted from contains a large amount of kerogen, and is known as oil shale.

This shale containing kerogen is essentially a precursor to oil or natural gas, as with increased pressure and a longer time period it could eventually become oil or natural gas.

It is important to note that shale oil is extracted from oil shale, which is different from oil-bearing shale. Oil-bearing shale contains petroleum that is trapped tightly in the rock itself and requires **hydraulic fracturing** to extract the oil, while shale oil is obtained from oil shale through a process of heating

Currently, oil shale isn't produced on a large scale as a result of the expensive processes needed to extract and upgrade the material and the potentially significant environmental effects when compared to conventional drilling.

Extraction

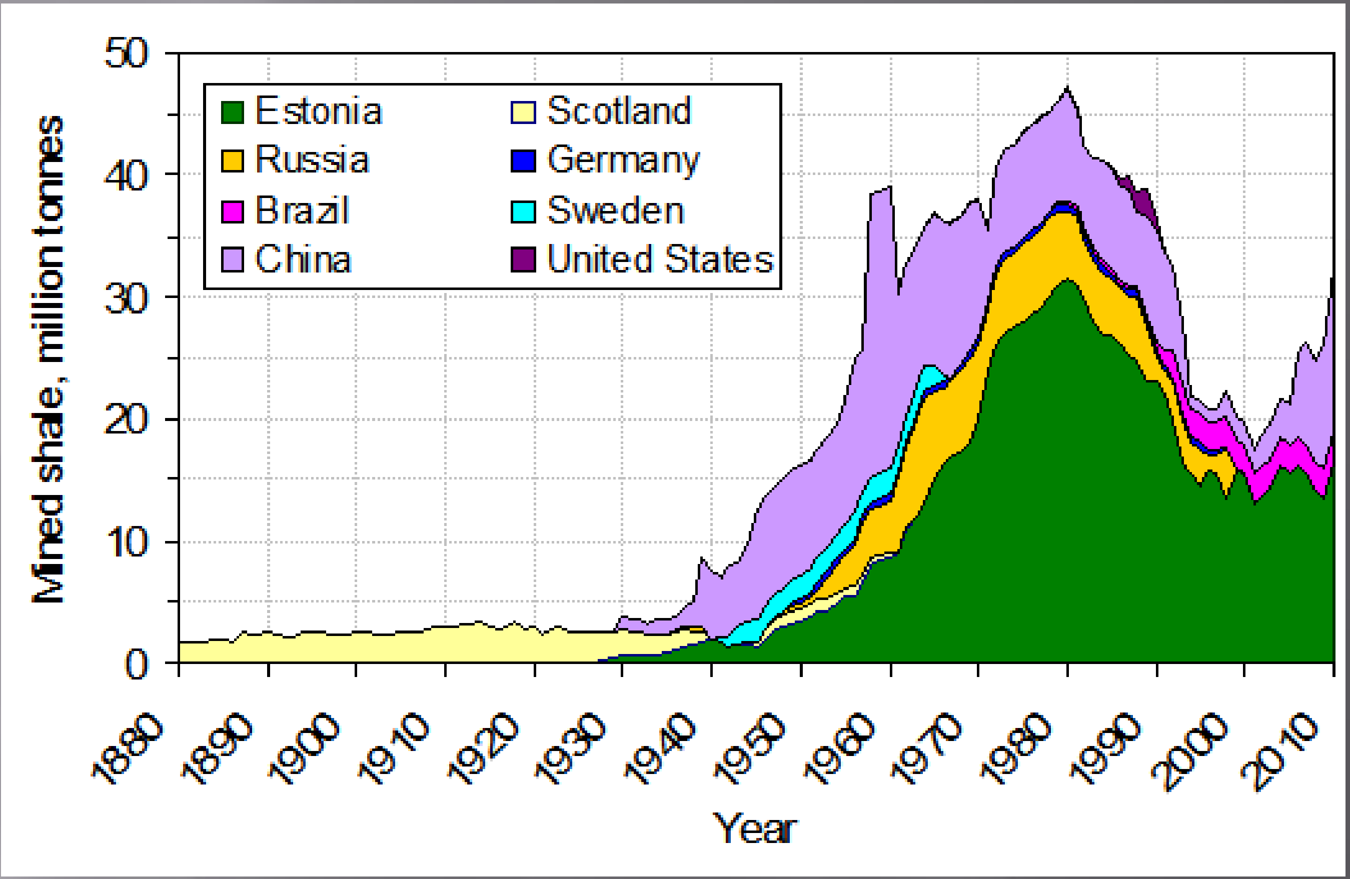
Oil shale must be first extracted from the ground with either underground or surface-mining methods.

After the process of extraction is complete, oil shale undergoes a process known as **retorting**.

During retorting, the shale containing the oil undergoes a process of pyrolysis to convert the oil into a liquid that can be removed more easily. This pyrolysis - which takes place in a vessel known as a **retort** - is simply a process of exposing the rock to high temperatures *without* oxygen being present.

This results in a chemical change in the rock. The kerogen - which is the fossil fuel trapped in the shale - liquefies and separates from the rock as an oily substance.

The oily substance extracted from the kerogen at this point is *not* actually crude oil. The substance obtained from the pyrolysis must undergo a **refining** process to change the substance into a synthetic crude oil that can be used.



Estonia
Scotland
Russia
Germany
Brazil
Sweden
China
United States
Mined shale, million tonnes
0
10
20
30
40
50
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

Oil sands

Oil sands are a mixture of sand, clay, water, and bitumen that occur naturally.

Bitumen is the fossil fuel component of this sand, and it is a very viscous oil that must be treated and upgraded before it can be used to produce useful fuels such as gasoline.

Oil sand deposits are found around the globe in the Middle East, Venezuela, Canada, the United States, and Russia. The largest deposit in Canada (and potentially the world) is the Athabasca deposit in Northern Alberta, Canada. It is the most developed deposit in the world, meaning that it has the most established and ongoing mining of any oil sands deposits.

Venezuela – 304 billion barrels
Venezuela has the largest oil reserves of any country in the world, with more than 300 billion barrels of proven reserves.
The country also has large deposits of oil sands, like those present in Canada.
Due to their viscous nature, Venezuela's Orinoco tar sands can be produced using conventional methods.

Formation

Like crude oil, the bitumen that exists in the oil sands began as living, organic material. It is speculated that the oil sands formed as a result of ancient oceans that existed millions of years ago, covering the areas where the oil sands exist today.

As the microscopic marine life within the oceans died, they decomposed with the help of bacteria. The bacteria removed the oxygen and nitrogen, leaving mainly hydrogen and carbon.

Heat and pressure then resulted in the layering of rock, silt, and sand over time and "cooked" the dead organic material for millions of years at temperatures between 50 and 150°C.

This formation of oil is similar to that of other deposits of lighter oils except that the lighter hydrocarbon fractions may have been lost during migration and/or the heavy oil is the component that remained following bacterial degradation.

The second theory is that bitumen was formed immediately in a process similar to the formation of oil shale. In this theory, bitumen was released from shales with a large amount of organic matter (kerogen rich shales) instead of crude oil being released.

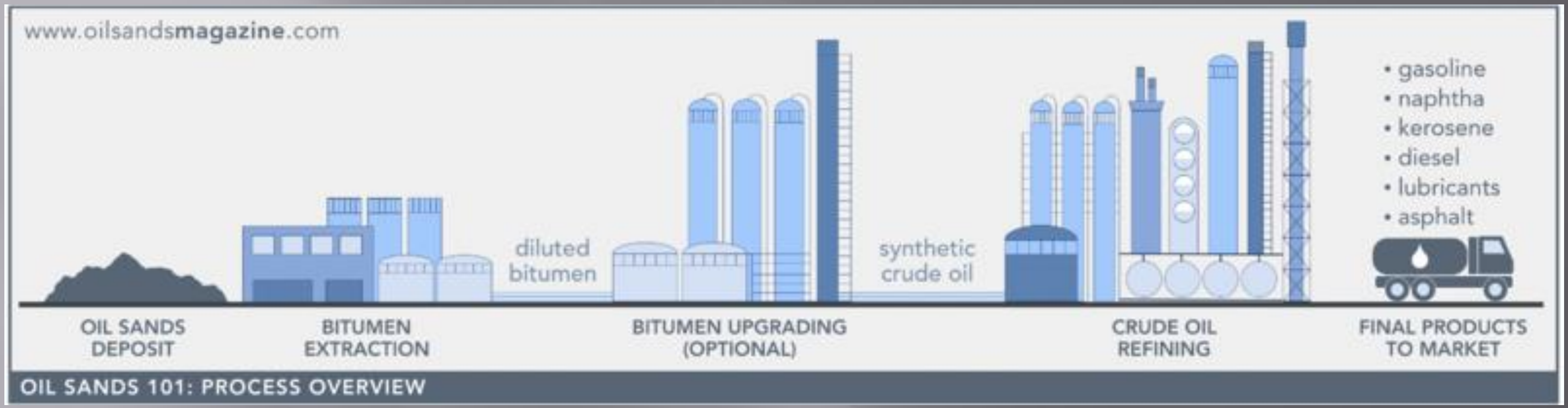
Terminology

here are three terms that are generally used for oil sands deposits: oil sands, tar sands, and bituminous sands.

Oils sands is the most widely used term, the term tar sands is often used by people who wish to make a statement about the negative environmental impacts of oil sands.

The term **bituminous sands** would be the most accurate term to use, since it is composed of bitumen and sand rather than tar or oil.

Extraction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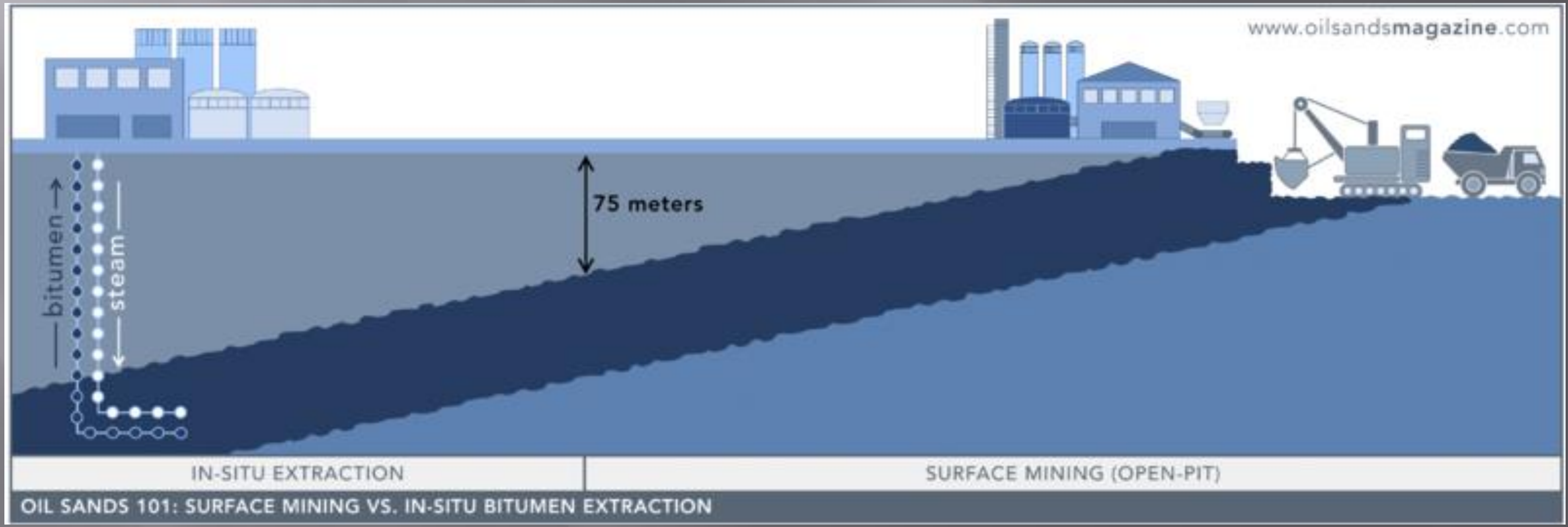
BITUMEN UPGRADING (OPTIONAL)
CRUDE OIL REFINING
FINAL PRODUCTS TO MARKET
OIL SANDS 101: PROCESS OVERVIEW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steam
75 meters
IN-SITU EXTRACTION
SURFACE MINING (OPEN-PIT)
OIL SANDS 101: SURFACE MINING VS. IN-SITU BITUMEN EXTRACTION

Unconventional Natural Gas

Unconventional natural gas is simply natural gas obtained by methods that are different from traditional extraction.

Unconventional natural gas can refer to

1. tight gas - natural gas locked in low-permeability rocks,
2. shale gas - natural gas locked in shale, or
3. coal bed methane - natural gas contained in coal.

The extraction of natural gas from these deposits can be an issue, as arguments about the environmental impact of **hydraulic fracturing** can be brought up.

Additionally, the water use in the extraction of coal bed methane can be an environmental concern

Tight gas

Tight gas is natural gas trapped within a rock with extremely low permeability—typically limestone or sandstone. This is not to be confused with shale gas, which is natural gas trapped within shale formations. Tight gas is considered to be an unconventional source of natural gas because it requires significant hydraulic fracturing—a much more extensive process—to access the gas. This is because the low permeability of the rock (meaning the pores within the stone are poorly connected), makes it difficult for the gas to travel through them.

Formation

Tight gas is formed in the same general way as conventional natural gas deposits, the main difference being the age of the deposits. Conventional gas is relatively young whereas tight gas formed around 248 million years ago in Palaeozoic formations. Over this long period of time, a conventional gas reserve was changed by cementation and recrystallization. This led to reduced permeability of the rock and natural gas being trapped tightly within rock formations.[4] Most tight gas formations are found onshore.

Horizontal or directional drilling are used to access tight gas deposits as they can run along the formation, allowing more opportunities for the natural gas to enter the well. In addition, numerous wells can be drilled into a tight gas deposit so that more of the formation is accessed.

Once a well is drilled down to a tight gas deposit, artificial stimulation can be used to promote the flow of tight gas from the rock. Hydraulic fracturing is one main method used to access the gas, and this method involves breaking apart the rocks in the formation by pumping the well full of high pressure fracking fluids.

This improves permeability and allows gas to flow more easily. Acidizing the well—or pumping the well full of acids to dissolve the limestone and sediment—allows the gas to flow more freely by establishing paths for the gas to follow

Finally, **deliquifaction** of the tight gas wells can help with extraction. In most tight gas formations the reservoirs also contain some water which can collect and make extraction difficult. Deliquefying by pumping water up from the reservoir makes removing the gas more simple.

Shale gas

Shale gas is a type of natural gas that is trapped within shale formations—arrangements of fine-grained sedimentary rock that are known as "natural gas plays" if they contain significant amounts of natural gas.

This type of natural gas is "contained in" shale formations and absorbed into organic matter. Shale is a common sedimentary rock composed of clay and fragments of other minerals. Shale can be the source, reservoir rock, or the seal for natural gas.

In Canada, shale gas resources are found in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia. Most of the current drilling occurs in British Columbia.

Exploration

Finding shale gas uses the same basic methods for exploring for traditional petroleum deposits combined with specialized techniques for finding shale gas. 2D and 3D seismic profiles (generated by monitoring acoustic waves that have reflected off of rocks) are used for determining the depth and properties of shale deposits and drilling is used to observe the rock's physical and chemical characteristics while determining the quality and quantity of the shale gas.

There are two major drilling techniques that are used to access shale gas. The first of these is horizontal drilling, which is where a well is drilled into the rock formation that starts going straight down, and then bends so that there is a horizontal part to the borehole as well. When the rock formation is hit, the drill bit is moved to drill horizontally which exposes the well to more of the shale that is producing the gas. The horizontal section of the well bore is usually from 1 to 3 kilometres long.

The second method is known as **hydraulic fracking** or **hydrofracking** (or sometimes just **fracking**). In this technique water, chemicals, and sand are pumped into the shale gas well. This opens fractures in the rock and allows natural gas from the shale to flow into the well. Without these techniques, natural gas does not flow to the well quickly and the wells are not economical.

Coal bed methane

Coal bed methane is methane trapped in underground coal seams. This type of methane can be accessed using drilling techniques similar to those used in the collection of shale gas.

In these deposits, the methane is attached to the surface of the coal. Generally, the seams are also covered in water which must be pumped out to obtain the methane. Pumping out the water reduces the pressure level and allows methane to escape from the seam.

Coal bed methane is considered an unconventional gas as it is held tightly in reservoirs and it requires special stimulation and technologies to produce it economically.

Methane, CH_4, is the main component of natural gas, so extracted coal bed methane can be used as natural gas. Although it tends to be more difficult to access than conventional gas, coal bed methane is becoming a significant energy source. In 2000, 1.2 tcf of coal bed methane was produced.

Formation

Coal bed methane forms at the same time coal forms. As organic material dies and is deposited in swamps or swampy lakes, the material undergoes bacterial and chemical changes to create peat deposits.

Over millions of years, this peat gets buried under many layers of sediment the pressure and temperature of the peat increases. Gradually, the peat turns into lignite or brown coal, then sub-bituminous coal, bituminous coal, and finally hard anthracite coal.

While coal is being formed, the decomposing organic material produces methane gas - the main component of natural gas - along with nitrogen and carbon dioxide. With the pressure of being buried under sediment, most of the methane stays trapped on the surface of the coal.

Extraction

Coal bed methane is considered to be an unconventional resource because it's difficult to access.

The extraction of coal bed methane is similar to the extraction of shale gas. First, a well is drilled into a coal seam. Then the sides of the well are cased with a cemented steel pipe, and small holes known as **perforations** are made in the walls of the casing in order to allow the methane gas to flow into the bore hole and up the well to the surface.

These wells are often drilled horizontally to gain access to difficult to reach coal seams. As well, for methane that is attached tightly to the coal seam the seams are generally fractured to allow the gas to flow freely. Some seams produce less water than others, and these are known as "dry coal bed methane wells". After the coal bed methane gas is removed, the coal seam remains and can be mined later on.

What are gas hydrates?

Gas hydrates are crystalline solids that form from mixtures of water and light natural gases such as methane, carbon dioxide, ethane, propane and butane.

Methane was the dominant component among other hydrocarbon gases in the sediments.

Gas hydrates are ice-like crystalline solids formed from a mixtures of water and natural gas, usually methane. They occur where pressure, temperature, gas saturation, and local chemical conditions combine to make them stable.

Gas hydrates are important for these reasons:

They may contain a major energy resource

It may be a significant hazard because it alters sea floor sediment stability, influencing collapse and landsliding

The hydrate reservoir may have strong influence on the environment and climate, because methane is a significant greenhouse gas.

Gas hydrates were discovered in 1810 by Sir Humphrey Davy, and were considered to be a laboratory curiosity. In the 1930s clathrate formation turned out to be a major problem, clogging pipelines during transportation of gas under cold conditions.

Sub-seabed methane within the continental margin sediments is produced primarily by microbial or thermogenic processes. In the microbial process organic debris are decomposed by a complex sequence (methanogenesis) into methane, by bacteria in an anoxic environment. Organic matter is composed of carbon, hydrogen and phosphorus in the ratio of 106:16:1, and decomposition results in production of methane.

the over 160m3 of methane trapped within each 1m3 of hydrate

Most low molecular weight gases, including O_2, H_2, N_2, CO_2, CH_4, H_2S, Ar, Kr, and Xe, as well as some higher hydrocarbons and freons, will form hydrates at suitable temperatures and pressures. Clathrate hydrates are not officially chemical compounds, as the enclathrated guest molecules are never bonded to the lattice. The formation and decomposition of clathrate hydrates are first order phase transitions, not chemical reactions.

Clathrates have been found to occur naturally in large quantities. Around 6.4 trillion (6.4×10^{12}) tonnes of methane is trapped in deposits of methane clathrate on the deep ocean floor.

Clathrates can also exist as permafrost, as at the Mallik gas hydrate site in the Mackenzie Delta of northwestern Canadian Arctic.

Gas hydrate deposits may contain roughly twice the carbon contained in all reserves of coal, oil, and conventional natural gas combined, making them a potentially valuable energy resource.

Their decomposition can release large amounts of methane, which is a greenhouse gas that could impact Earth's climate. Sudden release of pressurized methane gas may cause submarine landslides, which in turn can trigger tsunamis.

Gas hydrates in the ocean can be associated with unusual and possibly unique biological communities that use hydrocarbons or hydrogen sulfide for carbon and energy, via a process known as chemosynthesis.