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Department of chemical engineering and petroleum industries

(Storage and transportation of petroleum products)

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Lecture (6)

Facilities and processes

The oil and gas industry facilities and systems are broadly defined, according to their use in the oil and gas industry production stream:

Exploration Includes prospecting, seismic and drilling activities that take place before the development of a field is finally decided.

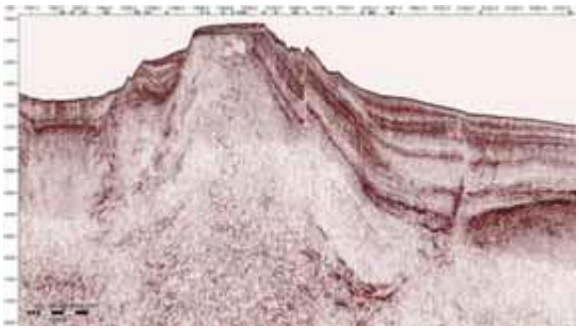
Upstream Typically refers to all facilities for production and stabilization of oil and gas. The reservoir and drilling community often uses upstream for the wellhead, well, completion and reservoir only, and downstream of the wellhead as production or processing. Exploration and upstream/production together is referred to as E&P.

Midstream Broadly defined as gas treatment, LNG production and regasification plants, and oil and gas pipeline systems.

Refining Where oil and condensates are processed into marketable products with defined specifications such as gasoline, diesel or feedstock for the petrochemical industry. Refinery offsites such as tank storage and distribution terminals are included in this segment, or may be part of a separate distributions operation.

Petrochemical These products are chemical products where the main feedstock is hydrocarbons. Examples are plastics, fertilizer and a wide range of industrial chemicals.

Exploration:



In the past, surface features such as tar seeps or gas pockmarks provided initial clues to the location of shallow hydrocarbon deposits. Today, a series of surveys, starting with broad geological mapping through increasingly advanced methods such as passive seismic, reflective seismic, magnetic and gravity surveys give data to sophisticated analysis tools that identify potential hydrocarbon bearing rock as "prospects." Chart: Norwegian Petroleum Directorate (Barents Sea)

An offshore well typically costs $30 million, with most falling in the $10-$100 million range. Rig leases are typically $200,000 - $700,000 per day. The average US onshore well costs about $4 million, as many have much lower production capacity. Smaller companies exploring marginal onshore fields may drill a shallow well for as little as $100,000. This means that oil companies spend much time on analysis models of good exploration data, and will only drill when models give a good indication of source rock and probability of finding oil or gas. The first wells in a region are called wildcats because little may be known about potential dangers, such as the downhole pressures that will be encountered, and therefore require particular care and attention to safety equipment.
If a find (strike, penetration) is made, additional reservoir characterization such as production testing, appraisal wells, etc., are needed to determine the size and production capacity of the reservoir in order to justify a development decision.

Production

This illustration gives an overview of typical oil and gas production facilities:

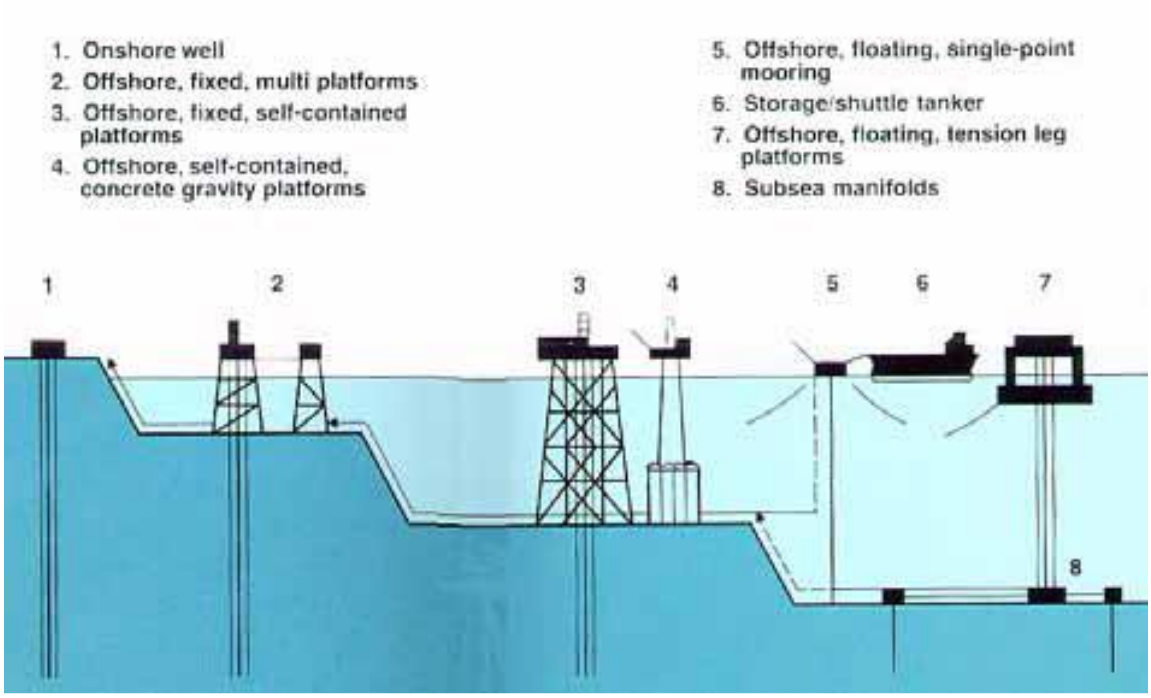


Figure 1. Oil and gas production facilities

Although there is a wide range of sizes and layouts, most production facilities have many of the same processing systems shown in this simplified overview:

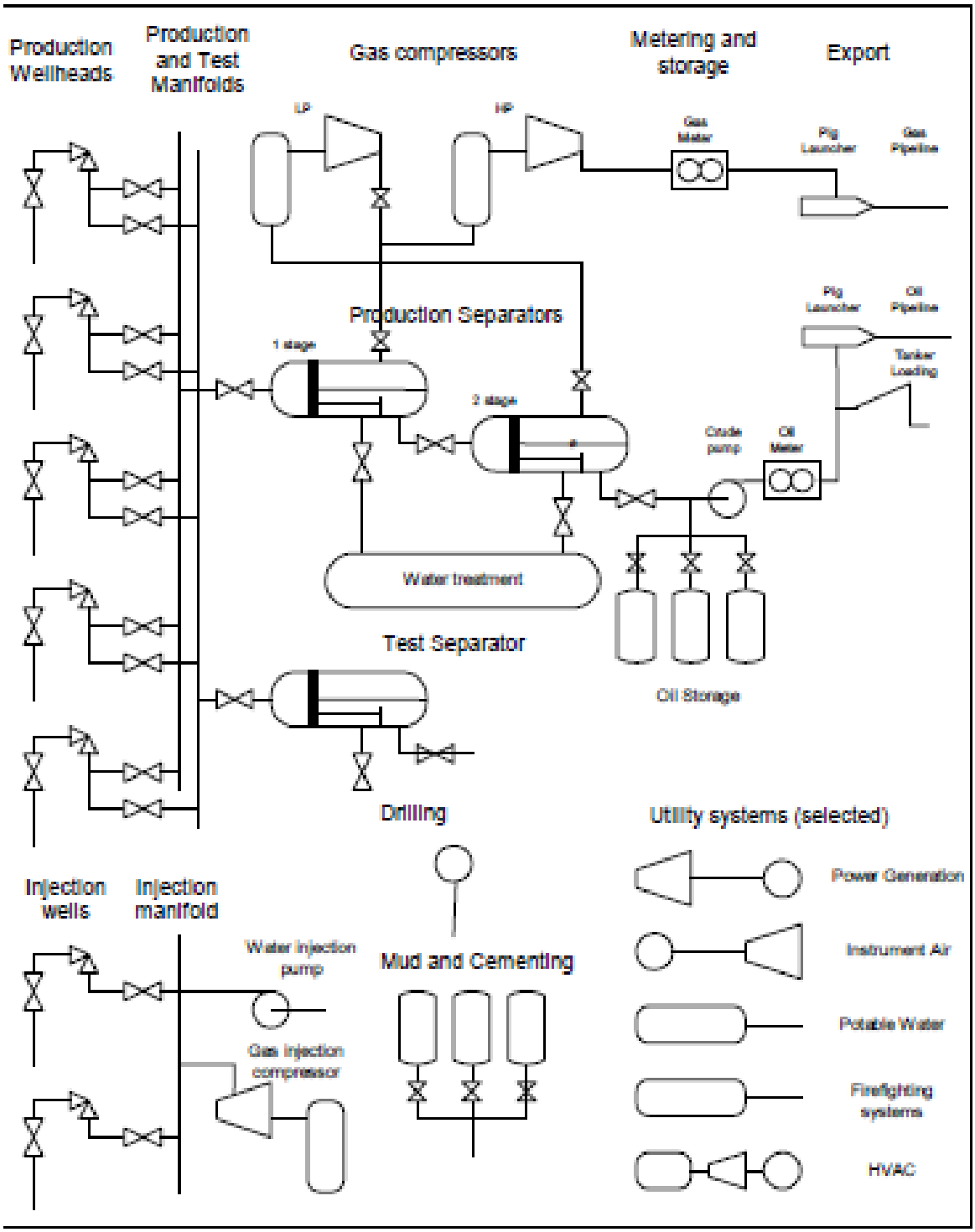


Figure 2. Oil and gas production overview

Today, oil and gas is produced in almost every part of the world, from the small 100 barrels-a-day private wells to the large bore 4,000 barrels-a-day wells; in shallow 20 meter deep reservoirs to 3,000 meter deep wells in more than 2,000 meters of water; in $100,000 onshore wells and $10 billion offshore developments. Despite this range, many parts of the process are quite similar in principle. At the left side, we find the wellheads. They feed into production and test manifolds. In distributed production, this is called the gathering system. The remainder of the diagram is the actual process, often called the gas oil separation plant (GOSP). While there are oil- or gas-only installations, more often the well-stream will consist of a full range of hydrocarbons from gas (methane, butane, propane, etc.), condensates (medium density hydrocarbons) to crude oil. With this well flow, we also get a variety of unwanted components, such as water, carbon dioxide, salts, sulfur and sand. The purpose of the GOSP is to process the well flow into clean, marketable products: oil, natural gas or condensates. Also included are a number of utility systems, which are not part of the actual process but provide energy, water, air or some other utility to the plant.

Onshore

Onshore production is economically viable from a few dozen barrels of oil a day and upward. Oil and gas is produced from several million wells worldwide. In particular, a gas gathering network can become very large, with production from thousands of wells, several hundred kilometers/miles apart, feeding through a gathering network into a processing plant. This picture shows a

well, equipped with a sucker rod pump (donkey pump) often associated with onshore oil production. However, as we shall see

later, there are many other ways of extracting oil from a non free-flowing well. For the smallest reservoirs, oil is simply collected in a holding tank and picked up at regular interv
railcar to be processed at a refinery.

Onshore wells in oil-rich areas are also high capacity wells producing thousands of barrels per day, connected to a 1,000,000 barrel or more per 8 day GOSP. Product is sent from the plant by pipeline or tankers. The production may come from many different license owners, so metering of individual well-streams into the gathering network are important tasks. Unconventional plays target very heavy crude and tar sands that became economically extractable with higher prices and new technology. Heavy crude may need heating and diluents to be extracted. Tar sands have lost their volatile compounds and are strip-mined or can be extracted with steam. It must be further processed to separate bitumen from the sand. Since about 2007, drilling technology and fracturing of the reservoir have allowed shale gas and liquids to be produced in increasing volumes. This allows the US in particular to reduce dependence on hydrocarbon imports. Canada, China, Argentina, Russia, Mexico and Australia also rank among the top unconventional plays. These unconventional reserves may contain more 2-3 times the hydrocarbons found in conventional reservoirs. These pictures show the Syncrude Mildred plant at Athabasca, Canada *Photo: GDFL Jamitzky/Wikimedia* and the Marcellus Shale in Pennsylvania. *Photo: GDFL Ruhrfisch /Wikimedia*

Offshore

A whole range of different structures is used offshore, depending on size and water depth. In the last few years, we have seen pure sea bottom installations with multiphase piping to shore, and no offshore topside structure at all. Replacing outlying wellhead towers, deviation drilling is used to reach different parts of the reservoir from a few wellhead cluster locations. Some of the common offshore structures are:

1. **Shallow water complex**,

2. **Gravity base**

3. **Compliant towers**

4. **Floating production**,

5. FPSO: Floating Production, Storage and Offloading.

6. **Subsea production systems**