Petroleum Oil is currently the most widely used fossil fuel and accounts for about one third of global energy consumption. Unlike coal, which is primarily used as a fuel for electricity generation, oil is primarily used as a fuel for transportation. Oil is also used to manufacture plastics and other synthetic compounds ubiquitous to our everyday life. Crude (unprocessed) oil varies greatly in appearance depending on its composition. It is usually black or dark brown (although it may be yellowish, reddish, or even greenish). In the reservoir it is usually found in association with natural gas, which being lighter forms a gas cap over the oil.

Oil is made up of hydrocarbons which are molecules that contain hydrogen and carbon in various lengths and structures, from straight chains to branching chains to rings. Hydrocarbons contain a lot of energy and many of the things derived from crude oil like gasoline, diesel fuel, paraffin wax and so on take advantage of this energy.

### 4.4.1: Extraction

Oil is mainly obtained by drilling either on land **(onshore)** or in the ocean **(offshore)**. Early offshore drilling was generally limited to areas where the water was less than 300 feet deep. Oil and natural gas drilling rigs now operate in water as deep as two miles. Floating platforms are used for drilling in deeper waters. These self-propelled vessels are attached to the ocean floor using large cables and anchors. Wells are drilled from these platforms which are also used to lower production equipment to the ocean floor. Some drilling platforms stand on stilt-like legs that are embedded in the ocean floor. These platforms hold all required drilling equipment as well as housing and storage areas for the work crews.

Offshore oil producers are required to take precautions to prevent pollution, spills, and significant changes to the ocean environment. Offshore rigs are designed to withstand hurricanes. Offshore production is much more expensive than land-based production. When offshore oil wells are no longer productive enough to be economical, they are sealed and abandoned according to applicable regulations.

### 4.4.2: Processing and Refining

When extracted, crude oil consists of many types of hydrocarbons as well as some unwanted substances such as sulfur, nitrogen, oxygen, dissolved metals, and water all mixed together. Unprocessed crude oil is therefore, not generally useful in industrial applications and must first be separated into different useable products at a **refinery** (Figure 4.1). All refineries perform three basic steps: separation, conversion, and treatment in the processing and refining of crude oil.
During **separation**, the various products (hydrocarbons) are separated into different components (called **fractions**), by taking advantage of the differences in boiling temperature of the components. This process is called **fractional distillation** and involves heating up the crude, letting it vaporize and then condensing the vapor. The lightest components have the lowest boiling temperature and rise to the top while the heaviest which also have the highest boiling temperature remain at the bottom.

**Conversion** is the chemical processing in which some of the fractions are transformed into other products, for example, a refinery can turn diesel fuel into gasoline depending on the demand for gasoline. Conversion can involve breaking larger hydrocarbon chains into smaller ones (cracking), combining smaller chains into larger ones (unification) or rearranging the molecules to create desired products (alteration).

**Treatment** is done to the fractions to remove impurities such as sulfur, nitrogen and water among others. Refineries also combine the various fractions (processed and unprocessed) into mixtures to make desired products. For example, different mixtures of hydrocarbon chains can create gasolines with different octane ratings, with and without additives, lubricating oils of various weights and grades (e.g., WD-40, 10W-40, 5W-30, etc.), heating oil and many others. The products are stored on-site until they can be delivered to various markets such as gas stations, airports and chemical plants.

A 42 U.S. gallon barrel of crude oil yields about 45 gallons of petroleum products because of refinery processing gain. This increase in volume is similar to what happens to popcorn when it is popped. Gasoline makes up the largest fraction of all petroleum products obtained (Figure \(\PageIndex{2}\)). Other products include diesel fuel and heating oil, jet fuel, petrochemical feedstocks, waxes, lubricating oils, and asphalt.
4.4.3: Fracking for oil

Hydraulic fracturing, informally referred to as “fracking,” is an oil well development process that typically involves injecting water, sand, and chemicals under high pressure into a bedrock formation via the well. This process is intended to create new fractures in the rock as well as increase the size, extent, and connectivity of existing fractures. Hydraulic fracturing is a well-stimulation technique used commonly in low-permeability rocks like tight sandstone, shale, and some coal beds to increase oil flow to a well from petroleum-bearing rock formations (Figure \(\PageIndex{3}\)).

Energy development often requires substantial amounts of water, and hydraulic fracturing is no exception. Water is needed not only for the traditional drilling process, but also for the actual fracturing as well. Water is first mixed with chemicals and fine sands, then pumped at extremely high pressure into the shale rock to fracture it, forming pathways for the oil and gas to reach the well. The water is then recovered, along with the oil and gas.

There are concerns regarding the potential contamination of fresh groundwater resources from oil and gas extraction wells that use hydraulic fracturing; either from the petroleum resource being produced or from the chemicals introduced in the fracturing process. Fracking fluid flowback – the fluid pumped out of the well and separated from oil and gas – not only contains the chemical additives used in the drilling process but also contains heavy metals, radioactive materials, volatile organic compounds (VOCs) and hazardous air pollutants such as benzene, toluene, ethylbenzene and xylene. In some cases, this contaminated water is sent to water treatment plants that are not equipped to deal with some of these classes of contamination.

Figure \(\PageIndex{3}\): Schematic cross-section of general types of oil and gas resources and the orientations of production wells used in hydraulic fracturing. Source: US EPA (Public Domain)

4.4.4: Environmental Impacts of Oil

Burning petroleum oil products releases emission such as carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen oxides (NOₓ), and particulate material all of which are air pollutants that impact the environment as well as human health (see more on air pollution in Chapter 6). Petroleum also emits carbon dioxide which is a greenhouse gas. Exploring and drilling for oil may disturb land and ocean habitats. On land, extensive infrastructure such as road networks, transport pipelines and housing for workers are needed to support a full-scale drilling operation. These can pollute soil and water, fragment habitats, and disturb wildlife.

Human-caused oil spills in rivers and oceans harm ecosystems. Natural oil seepages do occur and may be a significant
Oil spills at sea are generally much more damaging than those on land, since they can spread for hundreds of nautical miles in a thin oil slick which can cover beaches with a thin coating of oil. This can kill sea birds, mammals, shellfish and other organisms it coats. Oil spills on land are more readily containable if a makeshift earth dam can be rapidly bulldozed around the spill site before most of the oil escapes, and land animals can avoid the oil more easily. The amount of oil spilled from ships dropped significantly during the 1990s partly because new ships were required to have a double-hull lining to protect against spills.

Leaks also happen when we use petroleum products on land. For example, gasoline sometimes drips onto the ground when people are filling their gas tanks, when motor oil gets thrown away after an oil change, or when fuel escapes from a leaky storage tank. When it rains, the spilled products get washed into the gutter and eventually flow to rivers and into the ocean. Another way that oil sometimes gets into water is when fuel is leaked from motorboats and jet skis.

When a leak in a storage tank or pipeline occurs, petroleum products can also get into the ground, and the ground must be cleaned up. To prevent leaks from underground storage tanks, all buried tanks are supposed to be replaced by tanks with a double lining.
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