Investigation of Current Petroleum Extraction and Refinement Process

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Petroleum is an important source of energy for everyday life. It is a fossil fuel that most people don't give a second thought about, but it is a resource that has a limited supply. Even though there is a limited supply of petroleum, which is also referred to as crude oil, it remains as one of the most prominent energy sources used. There are other sources of energy including wind, solar, hydroelectric, and fusion. The first three sources of energy are; wind energy, solar energy, and hydroelectric energy. Fusion is a newer type of energy source and it is still in the stages of development. Fusion energy comes from nuclear reactions and it is the opposite of fission. Fission releases energy and creates radioactive byproducts while fusion joins atoms together and releases energy. There is still a lot of work to be done with fusion energy so for the time-being, petroleum remains a popular energy source. Petroleum goes through many steps to be extracted and refined so that the oil can enter everyday lives.

Petroleum has toformbefore it is extracted and refined. The first two steps are deposition and burial. These steps are usually what people learn about in a typical science course. Petroleum is made from the remains of organisms that existed millions of years ago. These organisms include algae and plankton that were buried in the bottom of the ocean after their life cycle. Many layers of sediment, debris, and dirt piled on top of these organisms and created what we know as fossil fuels, including petroleum. Fossil fuels can also originate on land from the remains of plants and animals. It's a similar process to ocean fossil fuels, on land there are layers of sand, dirt, and rocks that hold the petroleum[1]. Although some people believe that there are just lakes of petroleum, rocks and layers can hold the petroleum as well.

Diagenesis is the physical and chemical changes that occur when petroleum is being formed[2]. This stage is usually where kerogen forms along with bitumen. Bitumen is a tarlike substance that is often used for resurfacing the road and roofing. After diagenesis, catagenesis is

the next step. The kerogen and bitumen are known as a source rock because the oil comes from the structure of these two. Catagenesis is also known as cracking because the source rock needs heat to turn it into petroleum and by getting enough heat, between 122 °F and 302 °F, into the structure, it starts to break apart and crack open[2]. Finally, the last step is the reservoir formation. From the cracking stage, the mixture of oil and gas will be less dense than rocks around and begin to work up to the surface. The mixture doesn't come up all the way to the surface, usually stopping under tougher layers of rocks that it can't pass and then extraction will occur[1].

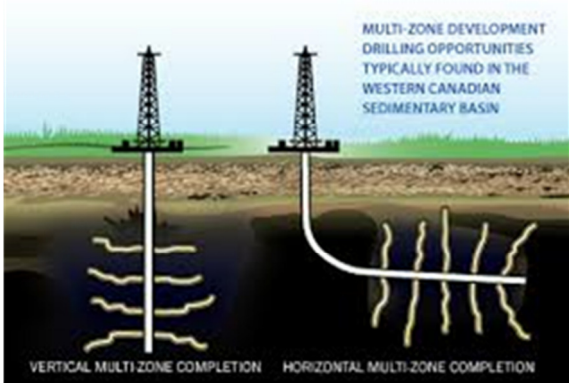
To get petroleum, first it must be located.Geologists are responsible for finding the locations where it can be drilled into[3]. By using rock formations and technology, geologists can find where crude oil flows. Seismology is also used by geologists to help locate oil. Seismology is the study of seismic, or energy, waves caused by earthquakes. These waves are referred to as shock waves and the rock density can be interpreted for signs of petroleum. Waves travel at different speeds and reflects through the earth and rock formations[4]. Geologists would interpret many different scenarios and features to determine if a spot was good for crude oil extraction. They would sometimes perform a shallow dig to collect samples to help them. Geologists are now able to interpret the surface of rocks and terrain along with previous methods of analyzing[3]. Petroleum also consists of many hydrocarbons and 'sniffers', which are electronic noses,used to detect hydrocarbons through smell[4].

After a petroleum reservoir has been located, a plan is made on how to extract the oil. Most petroleum will be extracted by creating a well and drilling into the ground. If the oil is in the ocean, sea or under a body of water, drilling rigs will be used depending on the situation of the oil. For a reservoir that is in shallow water, a jack-up rig is used. This is a smaller floating platform and will work to raise the rig above the water. Concrete platforms are ideal for water

depths greater than 150 meters and often used for storage and are very sturdy. A compliant tower is able to withstand lateral forces because of its narrow design. Barge rigs are large floating platforms and used in shallower waters. Submersible rigs are larger than a barge and more capable of deeper waters. This one can be submerged to a planned depth in case of rocky waters. A more common type of submersible rig is a semisubmersible rig. These ones are most common for offshore oil drilling and can operate down to 2000 feet$_5$. There are some more types of rigs for petroleum drilling and they all range from shallow to deep water. Each rig is used for different scenarios.

On land, drilling is a little different from drilling in a body of water. Drill rigs are also used on land and often wells are formed so that petroleum reservoirs can be used again after the first time. There are different types of drilling that varies depending on the location and how long the known site has been used. If a new location that has reservoirs has been found, then it is called exploratory drilling. The geologists will analyze petroleum reservoirs and surface location to determine if it is safe to drill there. Exploratory drilling can be dangerous if the area of the reservoir is not well known. Risks include any complications with the pressures and the likelihood of a dry drill[6]. If there has been drilling in an area before, then developmental drilling is used. Geologists and the team who drill the wells have already worked in the locations before, so they know the area that they are in. The goal is often to be as efficient as possible in getting the wells drilled. The last type is directional drilling and it connects with developmental drilling. This type is digging straight down to a known reservoir then angling the drill to reach more of the resources. The second well in the picture to the right shows how directional drilling can be done rather than keep the risk of drilling straight down. The second well is horizontal drilling. This drilling can increase production[7] and collects more petroleum unlike vertical drilling.

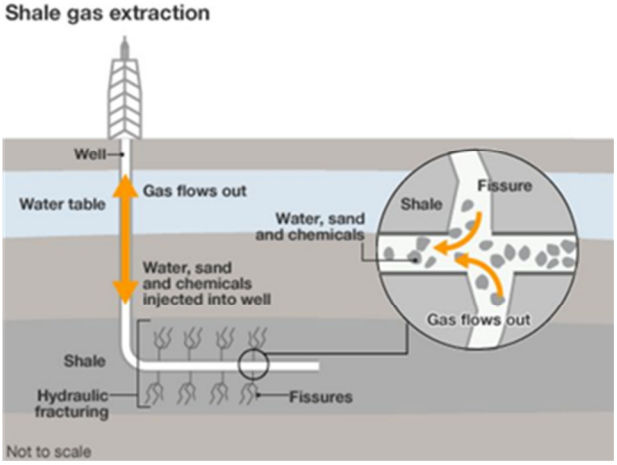
Figure 1: Ways to Drill[8]



Once the well forms then hydraulic fracturing, also known as fracking, can occur. Yet, there is controversy about using this method to extract the petroleum. Fracturing is used to extract oil and gases, but force open the rocks at a high pressure[9]. This method is disliked because there is an environmental cost of using a large amount of water to get the oil. There are

some people who feel that there is a reliance on petroleum and fossil fuels. They believe that fracking encourages that reliance instead of working for renewable energy. Fracking allow for companies to reach harder sources of oil. For the United States, it has driven down prices for oil and gas and boosts domestic production[9].

Figure 2: Diagram of Fracking[9]

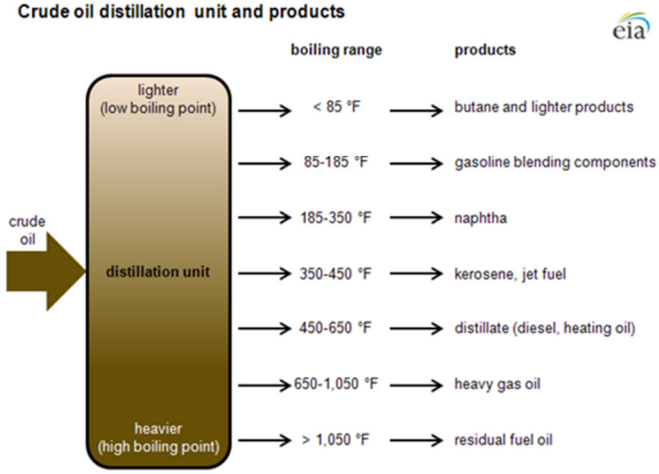


Fracking allows people to believe that are able to drill for any amount of oil at any time. This was prominent when the rising gas prices in 2012 created tensions with the government. Newt Gingrich and Rick Santorum wanted to work together for more oil to be extracted. They felt the Obama Administration was in the way of producing more petroleum. They felt they could meet the rising demands of oil that drilling[10]. As stated earlier, petroleum is a limited resource that isn't renewable like other sources of energy. Gingrich and Santorum wanted to meet the growing needs and lower gas prices. This was a topic during the 2012 election that the two felt strongly about pursuing. The planet is growing, and more energy is required to accommodate for them. Gingrich and Santorum believed that more energy is needed to power homes, transportations, food storage, filtration, and community facilities[10].

When petroleum is extracted, there are bits of impurities that come out with it. As stated earlier, petroleum is not one pure substance, it is composed of 98% carbohydrates which hydrogen and carbon are the main components[11]. Nitrogen, oxygen, and sulfur are all impurities in petroleum, along with sand and dirt that get mixed in when the oil is extracted. There are also

metals such as iron, nickel, and copper that are in petroleum in the ground. Sulfur is one of the more common impurities and the less sulfur that is in petroleum, the better because the refinement process is easier and requires less to do. These components and impurities are separated by fractional distillation, a process that separates liquids that vary in boiling points through distillation. Each layer has a different boiling point meaning that each component will become a vapor and rise to different levels before condensing individually. There are natural gases, types of gasoline, kerosene, fuel, and more that all can be originated from petroleum. Along with this, petroleum doesn't come out of the ground or sea ready to go, it must go through a refinement process to make it into the petroleum that we know and use.

Figure 3: Boiling points of components in petroleum[13]



The refinement process consists of three main steps that contribute to refining petroleum. The first step is separation. The molecules that are in crude oil are separated through atmospheric distillation. This step is important because it separates the components and sets a limit on the capacity so that the process doesn't overflow with petroleum. Through atmospheric distillation, the oil heats up to 700-750 degrees Fahrenheit[12]. There is a column where the oil is put into and vaporizes due to the high heat. All the vapors rise and go through different tubes or trays and then cools back down into a liquid. The components that are in vapor form will condense in levels because each component has different boiling and cooling

points. Not all products will vaporize since there are heavy oils and the column is only heated to a certain level.

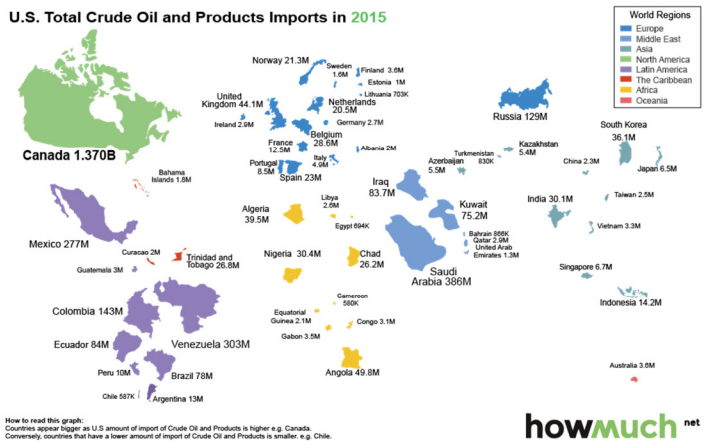
The next step in the refinement process is conversion. There is going to be more heavy molecules or heavy oil after the first separation process and the heavy oil isn't needed as much as lighter products are. The heavy molecules are then converted into lighter molecules through conversion, this is done at 932 degrees Fahrenheit[14]. 75% of these products will make it into a lighter substance and will be able to be used for gas, gasoline, and diesel[14]. This step can often be one of the more expensive steps as the refinement process is trying to remove carbons from the heavy oil to make it usable for what consumers need.

One last step in the refinement process is treating. This step is to take the petroleum and make it safe to use in everyday lives. Petroleum can have molecules that are toxic in the environment or dangerous to use. Toxic compounds include carbon monoxide and sulfur dioxide, sulfur being the most prominent in raw petroleum. Sulfur dioxide, with the chemical formula SO_2, is a colorless gas with a sharp odor that is produced by petroleum and fossil fuels[15]. SO_2 is also the main component of acid rain when it combines with water and air. Acid rain causes environmental hazards such as deforestation and acidifying water; health effects, primarily the respiratory system, and decreasing the quality of air[15]. This can create an additional step of desulfurization, which is the removal of sulfur from petroleum. Sulfur can't be more than 10 parts per million in gasoline and diesel, so the removal is necessary to be able to use petroleum. Desulfurization is done at a temperature of 698 degrees Fahrenheit and hydrogen is added in this process. Once the hydrogen is added, hydrogen sulfide (H_2S) forms and the sulfur is easier to remove from the oil[14].

Oil's payoff is a ratio of how many barrels can be produced and delivered with one barrel of oil. A payoff ratio is an item's average profit per trade divided by the item's average loss per trade. As a result, the higher that a payoff ratio is, the better the trade and/or production. When oil was starting to be extracted in the 1920s, the payoff was 100:1. In oil, the payoff ratio means that for every 100 barrels of petroleum, it takes one barrel to make and ship those 100 barrels. Although it seems like a small amount, the percent rate of return comes to about 10,000 percent[16]. But in 2012, the world production was a 20:1 ratio, and Canada, who produces oil from tar sands, had a production ratio of 5:1[16]. This means that it now takes one barrel to produce five barrels of oil. The ratio decrease shows that petroleum has gotten much more expensive. It takes more money to extract, refine, and ship petroleum than it did almost one hundred years ago. Renewable sources have ratios of 12:1, 15:1, and 17:1, showing that the rates for renewable energy are more sustainable than petroleum, which is about a 5:1 ratio.

Despite the ratios of barrels made from one barrel, they can be sold ranging from an average of $30 to $50. If a barrel is under $40, then production starts to slow down, and companies will begin to lose money if they continueto sell under $40[17]. When prices for oil gets too low, companies can decide to stop extracting and refining oil because production costs will be higher than profit. In 2015, it was taking almost $53 to produce one barrel of oil in the United Kingdom. Production in Brazil was close to $50 and in Canada, it was about $41 a barrel. At the time, oil was being traded at $42[18]. With these three countries, Canada is the only one who would be making money from oil trading. Imports and exports can still grow but it is hard to make money when costs to produce petroleum is higher than the trading cost.

Figure 4: How Much the U.S. Imports from other Countries



Petroleum comes from many different places in the world including the Middle East, Canada, United States, Latin America, and many more countries with their reserves. Most of the petroleum refinement and production comes from the Middle East, in 2014 they produced about 30% of oil barrels in the world. The Middle East includes Saudi Arabia, Iran, Iraq, and more countries that contributed to the 30%. Although the Middle East produces quite a bit of petroleum, the United States doesn't import from the Middle East as much. In 2012, the United States imported most of its petroleum sources from Canada and Latin America instead[19]. Saudi Arabia is the only country that the United States imports from the Middle East. Due to political pressures, the United States doesn't accept oil from Iran[19]. Some countries, like Venezuela, have had some tensions with the United States[19]. But that doesn't stop any shipments because of the closer distance and economic benefits. In 2010, oil imports fell in the United States, but Canada grew its exports by 129 million barrels. Canada continued growing its exports to the United States resulting in imports from other countries to decrease their sales of oil[20].

While the idea of sustainable resources grows more each day, petroleum remains prominent. Petroleum has a long history of importance; producing items, transportation, and trading. The United States imports a large amount from other countries to use in everyday life. Petroleum may have a lengthy process to go through, but has many benefits once completed. However, the extraction and refinement process should be improved. The components in

petroleum are not well known and there aren't set levels of how much are in it. There is not much known or written about the components. Knowing the components will enhance understanding of petroleum and how to work with it.

Reference Page

[1] Energy4me.org. Petroleum - Oil and Natural Gas | energy4me. [online] Available at: http://energy4me.org/all-about-energy/what-is-energy/energy-sources/petroleum/ [Accessed 2 Jan. 2019].

[2] Micu, A. What is petroleum, and where does it come from?. [online] ZME Science. Available at: https://www.zmescience.com/science/what-is-petroleum/ [Accessed 2 Jan. 2019].

[3] Petroleum.co.uk. Petroleum - Refining - Location and Extraction. [online] Available at: http://www.petroleum.co.uk/location-and-extraction [Accessed 2 Jan. 2019].

[4] Freudenrich, C. and Strickland, J. How Oil Drilling Works. [online] HowStuffWorks. Available at: https://science.howstuffworks.com/environmental/energy/oil-drilling2.htm [Accessed 2 Jan. 2019].

[5] Seyyedalangi, A. Types of Drilling Rigs and Structures. [online] Linkedin. Available at: https://www.linkedin.com/pulse/types-drilling-rigs-structures-ali-seyedalangi [Accessed 2 Jan. 2019].

[6] Trocquet, D. Exploratory vs. Development Drilling – Petro Prophet: Oilfield Education. [online] Petroprophet.com. Available at: https://www.petroprophet.com/exploratory-vs-development-drilling/ [Accessed 2 Jan. 2019].

[7] Rigzone.com. How Does Directional Drilling Work?. [online] Available at: https://www.rigzone.com/training/insight.asp?insight_id=295 [Accessed 2 Jan. 2019].

[8] Mapleleaffunds.ca. About Development Drilling. [online] Available at: http://www.mapleleaffunds.ca/royaltyincome/learningcentre/developmentdrilling.aspx [Accessed 2 Jan. 2019].

[9] BBC News. (2018). What is fracking?. [online] Available at: https://www.bbc.com/news/uk-14432401 [Accessed 2 Jan. 2019].

[10] Cohan, S. (2012). The Politics of Petroleum Prices and Our Energy Future. [online] HuffPost. Available at: https://www.huffingtonpost.com/steven-cohen/the-politics-of-petroleum_b_1320685.html [Accessed 2 Jan. 2019].

[11] Helmenstine, A. (2018). What Is Petroleum Made Of? Chemical Composition. [online] ThoughtCo. Available at: https://www.thoughtco.com/chemical-composition-of-petroleum-607575 [Accessed 2 Jan. 2019].

[12] Mckinseyenergyinsights.com. (n.d.). Atmospheric distillation. [online] Available at: https://www.mckinseyenergyinsights.com/resources/refinery-reference-desk/atmospheric-distillation/ [Accessed 2 Jan. 2019].

[13] Eia.gov. (2012). Crude oil distillation. [online] Available at: https://www.eia.gov/todayinenergy/detail.php?id=6970 [Accessed 2 Jan. 2019].

[14] PlanèteÉnergies. (2015). The Three Stages of Refining. [online] Available at: https://www.planete-energies.com/en/medias/close/three-stages-refining [Accessed 2 Jan. 2019].

[15] Qld.gov.au. (n.d.). Sulfur dioxide | Environment, land and water | Queensland Government. [online] Available at: https://www.qld.gov.au/environment/pollution/monitoring/air-pollution/sulfur-dioxide [Accessed 2 Jan. 2019].

[16] Margolis, J. (2012). The Energy Costs of Oil Production. [online] Public Radio International. Available at: https://www.pri.org/stories/2012-11-02/energy-costs-oil-production [Accessed 2 Jan. 2019].

[17] Schoen, J. (2015). When—and where—oil is too cheap to be profitable. [online] CNBC. Available at: https://www.cnbc.com/2015/01/12/oil-production-costs-when-and-where-the-price-of-crude-is-making-it-unprofitable.html [Accessed 2 Jan. 2019].

[18] Petroff, A. (2015). What it costs to produce a barrel of oil. [online] CNNMoney. Available at: https://money.cnn.com/2015/11/24/news/oil-prices-production-costs/index.html [Accessed 2 Jan. 2019].

[19] Flintoff, C. (2012). Where Does America Get Oil? You May Be Surprised. [online] NPR.org. Available at: https://www.npr.org/2012/04/11/150444802/where-does-america-get-oil-you-may-be-surprised [Accessed 2 Jan. 2019].

[20] MINING.com. (2016). How the US is shunning Saudi oil imports | MINING.com. [online] Available at: http://www.mining.com/web/how-the-us-is-shunning-saudi-oil-imports/ [Accessed 2 Jan. 2019].