Adkins Scholarship Foundation

"Gasoline: Where did it come from; how did it get here?"

Jennifer W. Leung

[redacted]

Harvest Christian Academy

Table of Contents

Introduction

In today's industrialized world, a majority of countries' economies depend largely on one thing: gasoline. With the United States consuming approximately 146 billion gallons a year[1], there is no doubt that if the U.S. were to use up all of its gasoline, the entire country would grind to a screeching halt. To get an idea of how vital gasoline is to everyday life, www.howstuffworks.com states that, "It is as vital to the economy as blood is to a person."[2] Gasoline is not only vital to everyday life, but recently rising gas prices became a major issue globally with headlines such as "Sudden Jump in Oil Prices as Gasoline Stocks Decline,"[3] "Pain at the Pump: New gas price records for third straight day," [4] and "Strong Possibility Gas Will Rise to $4". [5] (Chart 4)

With this in mind, the product I chose for the *Adkins Scholarship Research Project* is gasoline, and the motivation behind my choice of this product falls in the fact that I recently obtained my Driver's license. As happy as I was having finally gotten my license, in the back of my mind I knew gas prices were sky-rocketing and had already gone up to $4.12 per gallon. (Chart 1) So, when I was thinking of a product to do for the *Adkins Scholarship Research Project*, I was at a local Shell gas station, and I started wondering when I was filling up, where gasoline came from, and how it got on the island of Guam. As a result, I thought it was appropriate to do a research project on a product that I was genuinely interested in—gasoline. To carefully understand the whole process of how gasoline got onto our "shelves," I will trace back to the various distributors, wholesalers, retailers, and shipping methods that are responsible for getting the product onto the island of Guam.

---

[1] *"How much gasoline does the United States consume in one year?" 06 July 2000. HowStuffWorks.com. <http://auto.howstuffworks.com/question417.htm> 27 April 2008.*

[2] *Brain, Marshall. "How Gasoline Works." 06 February 2002. HowStuffWorks.com. <http://science.howstuffworks.com/gasoline.htm> 27 April 2008.*

[3] *OilVoice, Sudden Jump in Oil Prices as Gasoline Stocks Decline, April 03, 2008, http://www.oilvoice.com/n/Sudden_Jump_in_Oil_Prices_as_Gasoline_Stocks_Decline/f1d37625.aspx*

[4] *WSLS News Staff, Pain at the Pump: New gas price records for third straight day, April 23, 2008, http://www.wsls.com/sls/news/local/article/pain_at_the_pump_new_gas_price_records_for_third_straight_day/9759/>*

[5] *Dan Arnall, Strong Possibility' Gas Will Rise to $4, April 4, 2007, http://abcnews.go.com/Business/story?id=3007435&CMP=OTC-RSSFeeds0312*

Wholesaler, Retailer and Store operations

The first place to start in is the gas station where every consumer gets his or her gasoline. The gas station serves as the role of both retailer and wholesaler. The usual Shell gas station typically has around 16 pumps. (Appendix A)There is an attendant assisting people with problems encountered at the pump, a cashier in charge of receiving payments and controlling the gas flow, and a shift manager overseeing the store. The supply of gasoline that comes into the gas station can be traced back to tanker trucks[6] (Appendix B) that regularly deliver; the truck operator unloads each grade of gasoline into the appropriate underground tanks at the station, and the pumps we use today directly draw from the underground source. The tanks located in these trucks can typically hold up to 10,000 gallons and usually have several compartments which enable the transportation of different grades of gasoline.[7] The truck tanks are where the gas retailers have their own special additive package blended into the gasoline to differentiate one brand from another.

Shipping from distributor to wholesaler and retailer

From there, the gasoline can be traced back to the tank farms (Appendix C) where tanker trucks are first loaded with gas and headed for service stations.[8] (Chart 3)Tanker trucks from the tank farm also go to factories for industrial needs gasoline needs. (Chart 3) They serve as the shipment method from distributor to both the wholesaler and retailer.

Shipping from manufacturer to distributor

Tank farms are a place where, when refineries are done manufacturing gasoline, the gasoline is stored temporarily and later shipped off to various wholesalers and retailers. Furthermore, gasoline can get to tank farms in three ways: by way of pipelines (appendix E) which are directly connected from the refinery, barges (Appendix D) which ship from the refinery or tanker trucks who deliver straight from the refinery. [9]

---

[6] *Perez, Jonathan, Sales Manager, Shell, April 22, 2008*

[7] *EIA, Where Does My Gasoline Come From ?, http://www.eia.doe.gov/neic/brochure/gas06/gasoline.htm*

[8] *Perez, Jonathan, Sales Manager, Shell, April 22, 2008*

[9] *Perez, Jonathan, Sales Manager, Shell, April 22, 2008*

Manufacturing plant

The refinery, the place where gasoline is manufactured, is a crucial part in this whole process. Shell's refinery is located on the island of Pulau Bukom in Singapore, and is called the "Pulau Bukom Refinery." In the Pulau Bukom Refinery (Appendix G), crude oil is refined and made into gasoline by processes of separation, conversion, and treatment. To understand what a refinery does, it is important to know that crude oil is predominately composed of a mixture of hydrocarbons.[10] The refinery breaks down these hydrocarbons and makes the crude oil into the different products people use today, such as gasoline, diesel fuel, heating oil, jet fuel, liquefied petroleum gases, and residual fuel oil [11](Appendix H). The first step in converting crude oil into gasoline is separation. Because crude oil is made up of hydrocarbons, the most basic process is separating the crude oil into its "fraction." This process is called *fractional distillation*. Basically, what happens is the crude oil is heated and put into a still, or distillation column, and the different products boil off and are recovered at different temperatures. The lightest fractions, like gasoline and liquid petroleum gas (LPG), vaporize and rise to the top of the tower, where they condense back into liquids. (Appendix I) This is the point most refineries stop, but some refineries in the United States reprocess heavier fractions such as industrial fuel so they can maximize the output of the most desirable products.

The second step done in the refinery is conversion. The conversion method used in the Shell refinery is called "cracking".[12] It is called cracking because it uses heat and pressure to "crack" heavy hydrocarbon molecules into lighter ones (Appendix J). This allows refineries to utilize their crude oil resources more efficiently, making more products for which there is a high demand such as gasoline. Shell's refinery uses a fluid catalytic cracking unit (FCCU) which consists of one or tall, thick-walled, bullet-shaped reactors and a network of furnaces, heat exchangers and other vessels. [13] "The FCCU uses an extremely hot catalyst to crack the

---

[10] *Energy Information Administration Petroleum (Oil) -- A Fossil Fuel" http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html#How%20formed*

[11] *Energy Information Administration Petroleum (Oil) -- A Fossil Fuel" http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html#How%20formed*

[12] Shell "Refining and selling"http://www.shell.com/home/content/aboutshell-en/what_we_do/refining_selling/refining_selling_07112006.html

[13] *Hydrocarbons Technology "Pulau Bukom Refinery", Singapore" http://www.hydrocarbons-technology.com/projects/pulau/*

hydrocarbons into shorter chains." (Wisegeek)[14] Common catalysts used in an FCC unit are zeolite, bauxite, silica-alumina, and aluminum hydrosilicate.[15] "The oil and catalyst in the FCCU are usually extremely hot, and the oil is often in a vapor form."[16] The catalyst splits the long hydrocarbon chains into shorter units, and the mixture travels from the FCCU to another distillation column so that the cracked hydrocarbons can be extracted. [17]

The last step done in the refinery is treatment. The finishing touches usually occur during the final treatment. To make gasoline, refinery technicians carefully combine a variety of streams from the processing unit. There are many variables that determine the blend of gasoline. Variables like their octane level, vapor pressure ratings, and many special situations where gas is used, for example, if the gasoline will be used at high altitudes, on high performance engines, or if it is to the international global consumer standard.

Shipping of raw materials to manufacturer

After the crude oil is found, it is piped along the seabed to shore and to Shell's refinery, the Pulau Bukom Refinery in Singapore, or in some cases it can be stored on a floating storage and off-loading facility (FPSO). Then, if it is stored on a FPSO, it is transported from the FPSO to a storage facility and later transported to the refinery. (Appendix P)

Natural Resource

Before the crude oil is refined, or manufactured, crude oil is a natural resource and takes a lengthy amount of time to locate. Crude oil is first formed from the remains of plants and animals that have lived approximately millions of years ago. (Appendix K) Over a long period of time, the remains were covered by mud, sand, and other sediments and formed into sedimentary rock. The sediments are then compacted and transformed into layers of sedimentary rocks called "traps." The remains are covered with traps and undergo millions of years of extreme pressure

[14] *Conjecture Corporation "What is a Fluid Catalytic Cracking Unit (FCCU)?" 2003 – 2008 http://www.wisegeek.com/what-is-a-fluid-catalytic-cracking-unit-fccu.htm*

[15] *"Conjecture Corporation "What is a Fluid Catalytic Cracking Unit (FCCU)?" 2003 – 2008 http://www.wisegeek.com/what-is-a-fluid-catalytic-cracking-unit-fccu.htm*

[16] *Conjecture Corporation "What is a Fluid Catalytic Cracking Unit (FCCU)?" 2003 – 2008 http://www.wisegeek.com/what-is-a-fluid-catalytic-cracking-unit-fccu.htm*

[17] *Conjecture Corporation "What is a Fluid Catalytic Cracking Unit (FCCU)?" 2003 – 2008 http://www.wisegeek.com/what-is-a-fluid-catalytic-cracking-unit-fccu.htm*

and high temperatures which transforms them into the mix of liquid hydrocarbon that is known as crude oil. [18]

To obtain gasoline, we must know if there is, in fact, crude oil located underground and if it can be acquired by drilling (Appendix L) To visualize what is underneath the earth, scientists must first locate where the crude oil is and utilize a process called seismic surveying. (Appendix M) Seismic surveying requires three components in order for it to work properly: seismic source, sensors, and recording equipment.[19] Through seismic surveying, scientists can actually see a "picture" of the rock layer structure by measuring the time it takes for the energy waves to reach the surface.[20] To see if exploration can begin, seismic data is then collected and processed.

The next step in obtaining the crude oil is exploration. To properly identify which traps contain oil within their rock formations, scientists look for "porous reservoir rocks which usually accumulate oil…", "an overlying impermeable rock to prevent oil and gas from escaping…", and "a source for oil and gas…"[21] Then, scientists use seismic surveying. In seismic surveying, several lines of sensitive receivers, called geophones or jugs, are laid out on the ground.[22] Next, explosions or mechanical vibrations are created on the surface and the geophones record the seismic waves from the rock layers at various depths.[23]

There are two kinds of ways to explore for oil—off shore and on shore exploration. In the scenario of off shore exploration, "air guns" are used instead of explosions.[24] Because they use compressed air, they have also come to replace dynamite to become a better, safer energy source and to reduce the negative impact on the marine life.[25] After all that is done, the seismic data is collected to be processed and interpreted to decide whether further testing is required or if exploration can finally begin.

---

[18] Energy Information Administration "Petroleum (Oil) -- A Fossil Fuel" http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html#How%20formed

[19] Shell "Oil & Gas - Exploration and Production" http://www.shell.com/home/Framework?siteId=eandp-en&FC2=/eandp-en/html/iwgen/zzz_lhn.html&FC3=/global/about_shell/what_we_do/eandp_swf/eandp_swf_offshoreprod_ga_0830.html

[20] EEI "Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html

[21] EEI "Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html

[22] CAPP "Finding Oil and Natural Gas" http://www.capp.ca/default.asp?V_DOC_ID=41

[23] EEI "Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html

[24] EEI "Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html

When it is decided exploration can go on, the drilling begins. Drilling is the only way to be certain what is contained underground and to determine whether a well would produce oil, gas, or both. The type of drilling technique used by Shell is called a "rotary drilling system."[26] A rotary drilling rig (Appendix N) is usually made up of hoisting equipment, drilling bit, drill pipe, rotary equipment, mud-circulating treating equipment, blowout prevention system, and power source. Drilling is a round-the –clock operation, so "a drilling supervisor leads a team of experts who work in shifts."[27] When seismic surveys and other miscellaneous data indicate that crude oil is present, an exploration well is drilled.

Then, onshore production commences. If commercial levels of crude oil for onshore production are found when drilling at a reservoir, a plan is designed to get maximum production rates for the lowest cost. "Once the decision to bring the reservoir on stream is made, wells are drilled and linked to the processing plant via a pipeline."[28] Afterwards, "flowing wells complete oil production by using cemented steel casing and pipes called "tubes,"[29] and "at the top of the tubing is a wellhead called a "Christmas tree," which is made up of a cluster of valves to control the flow of oil."[30] Pumps and other devices are often attached to the wellhead to increase the flow of the processing plant.[31] However, most of the time additional pumps and devices are not needed because flowing wells normally have enough pressure for the oil to flow onto the surface naturally. Sometimes the crude oil that flows to the surface may have impurities. For example, when the flowing well pumps crude oil out, it can sometimes come out of the same well with sand and other solid material. Also, the crude oil can be referred to as "sour" when there is hydrogen sulphide or carbon dioxide present and "sweet" when hydrogen sulphide or carbon dioxide is not.[32] There is really no set method in onshore production. The different oil fields encountered in onshore production require different methods of separation, transportation, and processing.

---

[25] EEI *"Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html*

[26] Shell *"Oil & Gas - Exploration and Production" http://www.shell.com/home/Framework?siteId=eandp-en&FC2=/eandp-en/html/iwgen/zzz_lhn.html&FC3=/global/about_shell/what_we_do/eandp_swf/eandp_swf_offshoreprod_ga_0830.html*

[27] EEI *"Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html*

[28] EEI *"Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html*

[29] EEI *"Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html*

[30] EEI *"Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html*

[31] EEI *"Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html*

[32] EEI *"Oil & Gas – The Exploration and Production Process" 2006 http://eei-inc.com/pages/explore.html*

In offshore production, crude oil is produced from multiple wells and brought to the surface via platforms. (Appendix O) Many wells can feed through to one platform. It is on the platforms the initial separation of gas, condensate, and oil is often undertaken and the size of the platforms usually depends on the size of the field, the amount of processing that is taken on the platform, and the distance from shore.

Environmental Aspect

Is the world running out of oil? Because of our thirst for gasoline, the only way to prevent crude oil from running out is to reduce demand. With the world consuming about 80 million barrels of oil a day[33], world oil supplies are running out faster than expected and the demand of oil is expected to increase. Some scientists have already begun to say that world production has already peaked, and some say we are very close to it. Although scientists are coming up with alternatives, it may not come in time. Therefore, start thinking green, and help reduce the consumption of gasoline. It may only last us around three decades. [34]

Financial aspects

In every step of this already complicated process there is also a financial aspect to it. Currently, gas prices are approximately $4.079/ gallon and $116[35] to the barrel. Before you blame the recent rise of Guam's gas prices on the retailer, according to Globe Petroleum, "nearly 90% of the price of a gallon of gasoline is determined before it has even reached your local convenience store."[36] Factors such as shipping, insurance, losses, facility fees, storage and handling, secondary transportation, retail site cost, more insurance for retail sites, environmental liability, health and safety, consumer information requirements, and taxes (LFT and GRT) all play a role in the pricing of the final product.[37] There are costs for the transportation of gas like chartering ships, cost to use pipelines, drivers, running costs of trucks, and transfer and

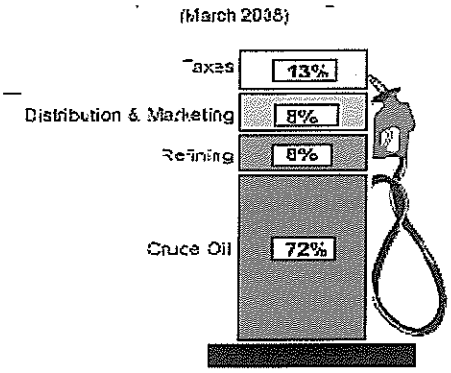
[33] *CBC News http://www.cbc.ca/news/background/oil/supply_demand.html*

[34] *Offshore Environment "Interesting facts about oil, gas and ocean environment" http://www.offshore-environment.com/facts.html*

[35] *Wong, Gillian "Oil near record above $115 a barrel" April 16, 2008*
http://www.rgj.com/apps/pbcs.dll/article?AID=/20080416/NEWS18/80416063

[36] *Globe Petroleum, "COMMERCIAL FUELS : The Price Difference" 2002 http://www.globepetroleum.com/price_difference.html*

[37] *Perez, Jonathan, Sales Manager, Shell, April 22, 2008*



evaporation losses.[38] There are costs for insurance such as freight and pollution insurance, worker insurance, general liability, workers compensation, and ship insurance.[39] Also, general costs such as building and maintaining facilities to standards, power, labor, rent, maintenance, and the cost of training the staff.[40]

The main reason for the rise in gas prices is the rise in the price of crude oil. Crude oil accounts for about 72% of every gallon pumped; federal, state, and local taxes account for 13% of every gallon. "Refining costs and profits alone take approximately 8% of every gallon spent to fill up your tank. The cost of distribution and marketing, along with retail dealer profits, together make up another 8%."[41] Gasoline prices are also affected by supply and demand. "The price of oil is set by a global market of buyers and sellers — each look at a variety of factors before deciding how much they are willing to pay or accept for a barrel of crude [oil]." Traders also look at economic trends that may show the demand for oil.[42] All in all, the oil producers are the ones that profit the most from the recent jump in gas prices, and the weak U.S. dollar does not help the market much either.

Conclusion

To apply what I have learned to everyday life, I have found out that gasoline has a great effect on other products. Because the price of gasoline has soared, so have the prices of other everyday commodities, and the economy has taken a large hit. Prices of eggs, flour, bread, and tomatoes have jumped as high as 25%. Not only that, the current global food crisis has left millions of people hungry, and the rise in gas prices has just aggravated the whole situation. The rise in gas prices also affects jobs. Truckers, who drive for a living, sometimes have to pay for gasoline out of their own pocket. Having to pay around $600 now, to fill up the tank of the truck,

[38] *Perez, Jonathan, Sales Manager, Shell, April 22, 2008*

[39] *Perez, Jonathan, Sales Manager, Shell, April 22, 2008*

[40] *Perez, Jonathan, Sales Manager, Shell, April 22, 2008*

[41] *EIA Gasoline and Fuel Update March, 2008 http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp*

[42] *Schoen, John W MSNBC April 20, 2006 http://www.msnbc.msn.com/id/12410064/*

many truckers are quitting. To get an idea of just how bad it is, for every cent a gallon gas goes up, it costs trucking companies around $400 million per year.[43] Just think about the cost of gas to fill up the ships which transport our food.

Gasoline has been a very sensitive subject globally. It basically affects many aspects of life I never knew it did. After completing this project, I have learned tremendously about the complex process of how and where the gas in our service stations comes from. I never really realized how and where products have come to be on the island of Guam, and this project has really opened my eyes and taught me to see in a whole other viewpoint. Whenever I go to supermarkets like Pay-Less or K-Mart, I find myself wondering about the products that they have and who the distributor is, and which wholesaler they got the product from. I guess this is a side effect in having done this project.

What I learned from this project is that getting a product to Guam is not easy, there are many financial and economic ties we, the consumer, do not see. This project has taught me so many new things, and I would be lying if I said I did not benefit in having done this project.

[43] *"Rising fuel costs give truckers a bumpy ride" Nightly News with Brian Williams*

Bibliography

Brain, Marshall. "How Gasoline Works." 06 February 2002. HowStuffWorks <http://science.howstuffworks.com/gasoline.htm> 27 April 2008.

"COMMERCIAL FUELS: The Price Difference" *Globe Petroleum* 2002 <http://www.globepetroleum.com/price_difference.html> 12 April 2008

"Finding and producing oil and gas" Shell <http://www.shell.com/home/content/eandp-en/how_we_work/finding_producing_oil_gas/finding_producing_oilandgas_10171225.html> 20 March 2008.

"Finding Oil and Natural Gas" CAPP < http://www.capp.ca/default.asp?V_DOC_ID=41> 25 April 2008

"Gasoline and Fuel Update" EIA, March 2008 <http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp> 27 April 2008

"Gasoline prices hit $3.49 in metro-east" Belleville News-Democrat Apr. 04, 2008 <http://www.bnd.com/179/story/299877.html> 25 March 2008

"How much gasoline does the United States consume in one year?" 06 July 2000. HowStuffWorks.com. <http://auto.howstuffworks.com/question417.htm> 27 April 2008.

"List of oil refineries" Wikipedia <http://en.wikipedia.org/wiki/List_of_oil_refineries#Singapore> 03 April 2008

"Interesting facts about oil, gas and ocean environment" Offshore environment < http://www.offshore-environment.com/facts.html> 27 April 2008

"Oil near record above $115 a barrel" Wong, Gillian April 16, 2008 <http://www.rgj.com/apps/pbcs.dll/article?AID=/20080416/NEWS18/80416063> 25 April 2008

"Oil & Gas - Exploration and Production" Shell <http://www.shell.com/home/Framework?siteId=eandp-en&FC2=/eandp-en/html/iwgen/zzz_lhn.html&FC3=/global/about_shell/what_we_do/eandp_swf/eandp_swf_offshoreprod_ga_0830.html > 21 March 2008

"Oil & Gas – The Exploration and Production Process" EEI 2006 < http://eei-inc.com/pages/explore.html> 22 April 2008

"Pain at the Pump: New gas price records for third straight day" WSLS News Staff April 23, 2008<http://www.wsls.com/sls/news/local/article/pain_at_the_pump_new_gas_price_records_for_third_straight_day/9759/> 25 March 2008

Perez, Jonathan, Sales Manager, Shell, April 22, 2008, Jonathan.Perez@shell.com

"Petroleum (Oil) -- A Fossil Fuel" Energy Information Administration <http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html#How%20formed> 20 March 2008

"Petroleum (Oil) – Refining" Energy Information Administration <http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/refinery.html> 20 March 2008

"Primer: Where does US gasoline come from?" Energy Publisher <http://www.energypublisher.com/article.asp?id=12363 > 09 April 2008

"Pulau Bukom Refinery", Singapore" Hydrocarbons Technology

<http://www.hydrocarbons-technology.com/projects/pulau/> 10 April 2008

"Refining and selling" Shell

<http://www.shell.com/home/content/aboutshell-en/what_we_do/refining_selling/refining_selling_07112006.html> 20 March 2008

Schoen, John W. MSNBC April 20, 2006

<http://www.msnbc.msn.com/id/12410064/> 26 April 2008

"Searching & recovering". Shell

<http://www.shell.com/home/content/aboutshell-en/what_we_do/searching_recovering/searching_recovering_07112006.html> 20 March 2008

"Strong Possibility" Gas Will Rise to $4" Dan Arnall ABC News

< http://abcnews.go.com/Business/story?id=3007435&CMP=OTC-RSSFeeds0312> 20 March 2008

"Sudden Jump in Oil Prices as Gasoline Stocks Decline" OilVoice April 03, 2008

<http://www.oilvoice.com/n/Sudden_Jump_in_Oil_Prices_as_Gasoline_Stocks_Decline/f1d37625.aspx> 21 April 2008

"What is a Fluid Catalytic Cracking Unit (FCCU)?" Conjecture Corporation 2003 – 2008

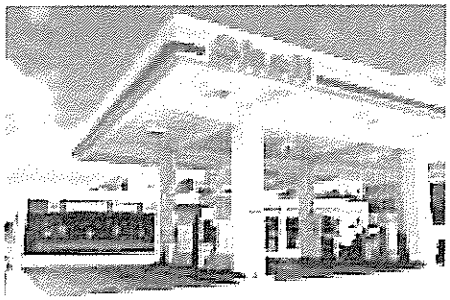
<http://www.wisegeek.com/what-is-a-fluid-catalytic-cracking-unit-fccu.htm> 14 April 2008

"Where Does My Gasoline Come From?" Energy Information Administration

<http://www.eia.doe.gov/neic/brochure/gas06/gasoline.htm> 17 April 2008

Appendix

Appendix A

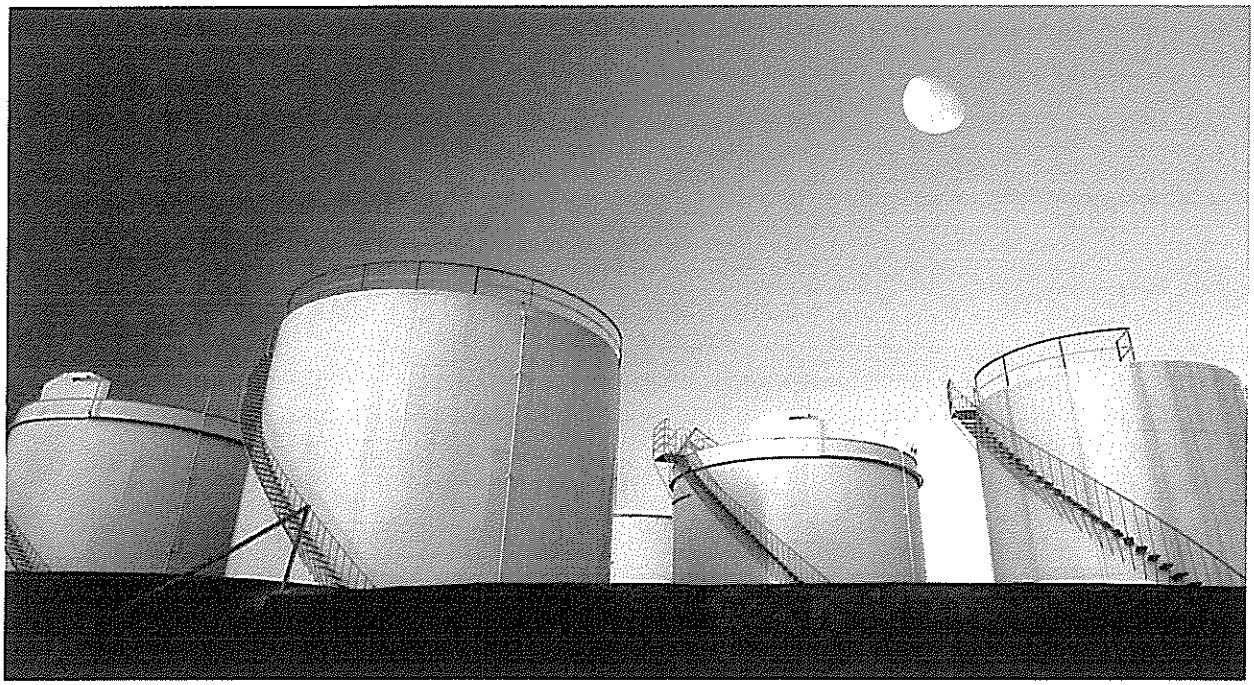


The Shell gas station located in Barrigada
[http://www-static.shell.com/static/gu-en/images/general/shell_barrigada_71.jpg]

Appendix B

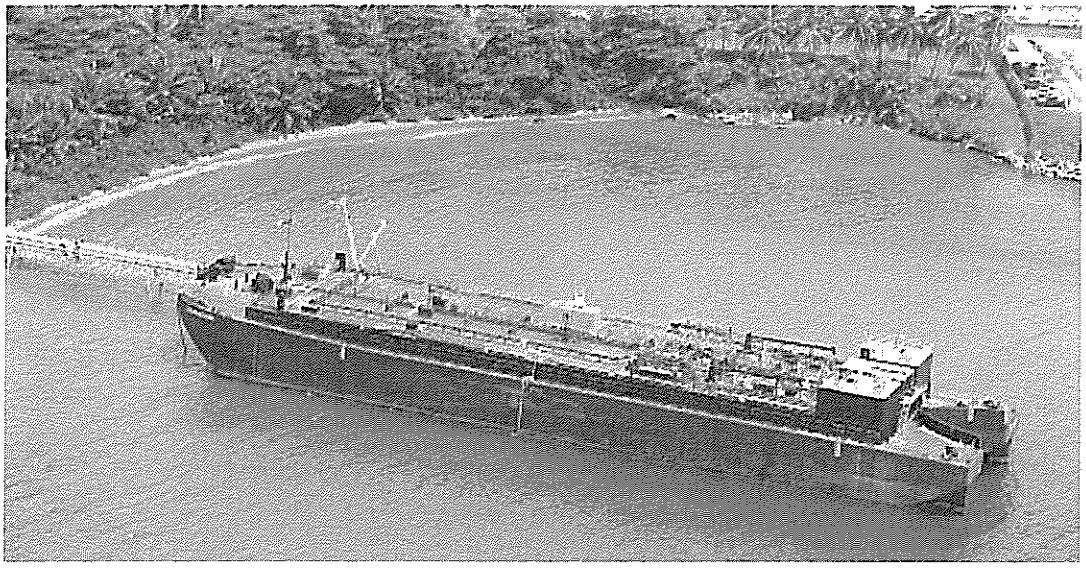
Shell Tanker
[http://www.morricoequipment.com/images/Shell%20pictures%202%20of%202/allied-shell-4.jpg]

Appendix C



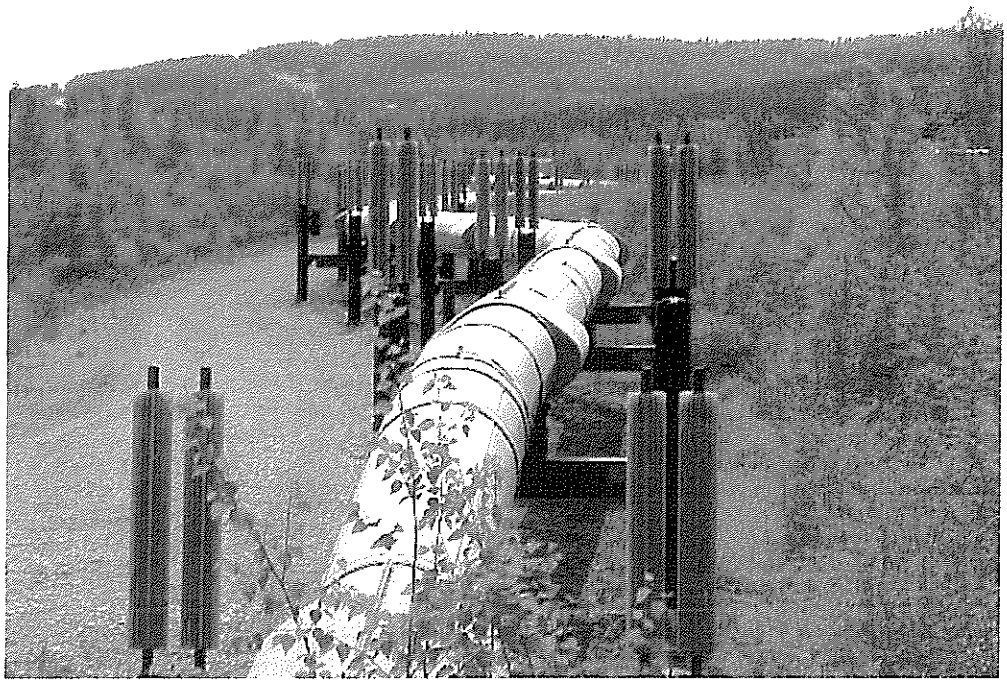
ConocoPhillips Tank Farm in Singapore
[http://www.the-eic.com/News/images/TankFarm4.jpg]

Appendix D



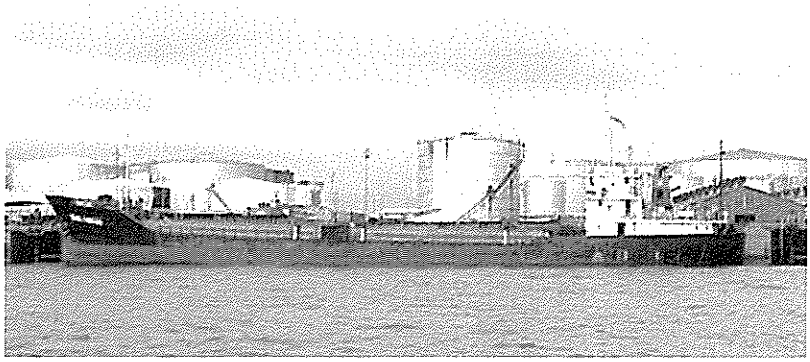
Barge
[http://www.morantug.com/images/towline_2003/newbarge1.jpg]

Appendix E



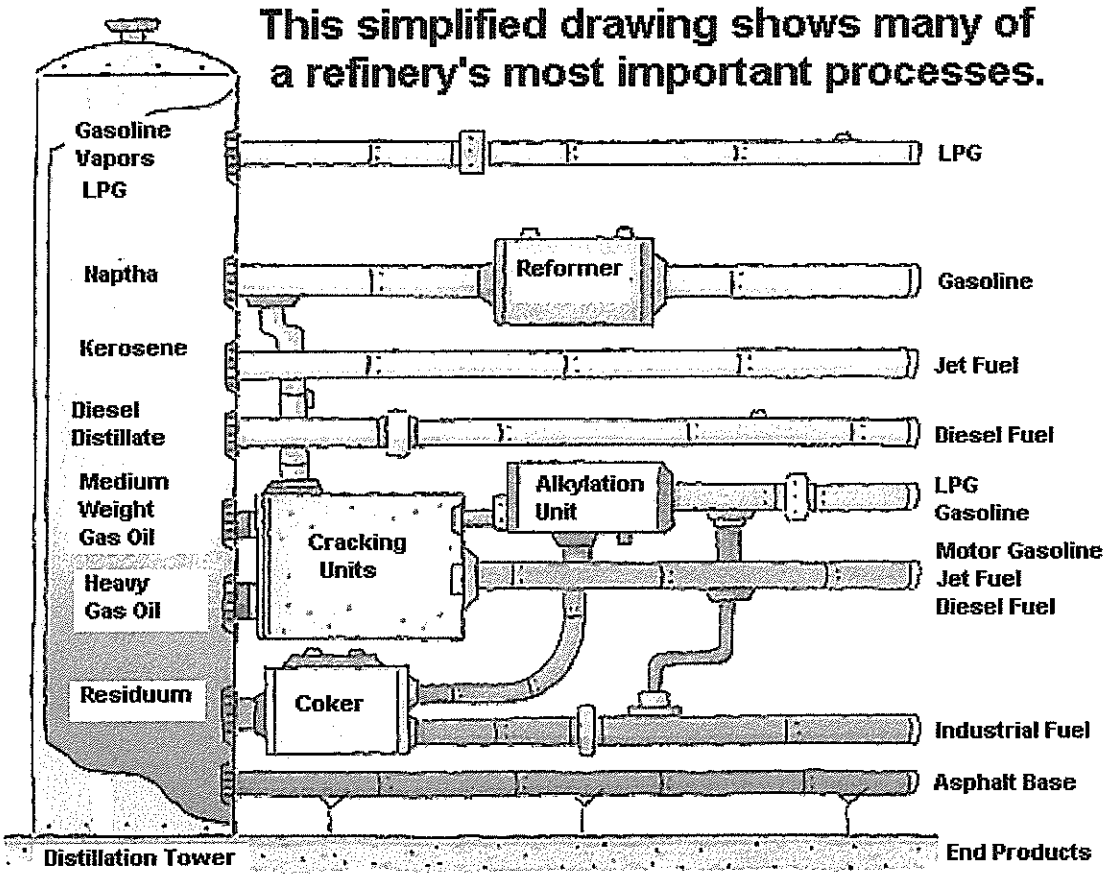
Pipeline
[http://www.bobhunter.org/Pipeline_zigzag.jpg]

Appendix G



Pulau Bukom Refinery
[http://bp2.blogger.com/_Vxu_tx5NynY/RoeZuolDWzI/AAAAAAAABLg/-NtG9b0bN1w/s400/070701hntd3123m6.jpg]

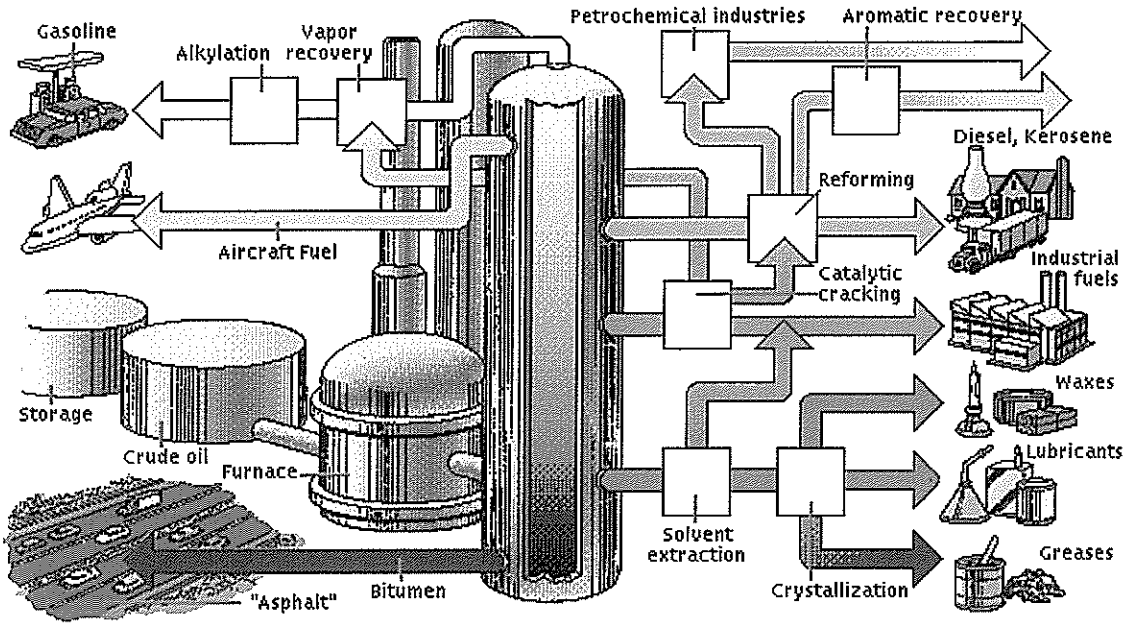
Appendix H



Fractional distillation

[http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/images/refinery.gif]

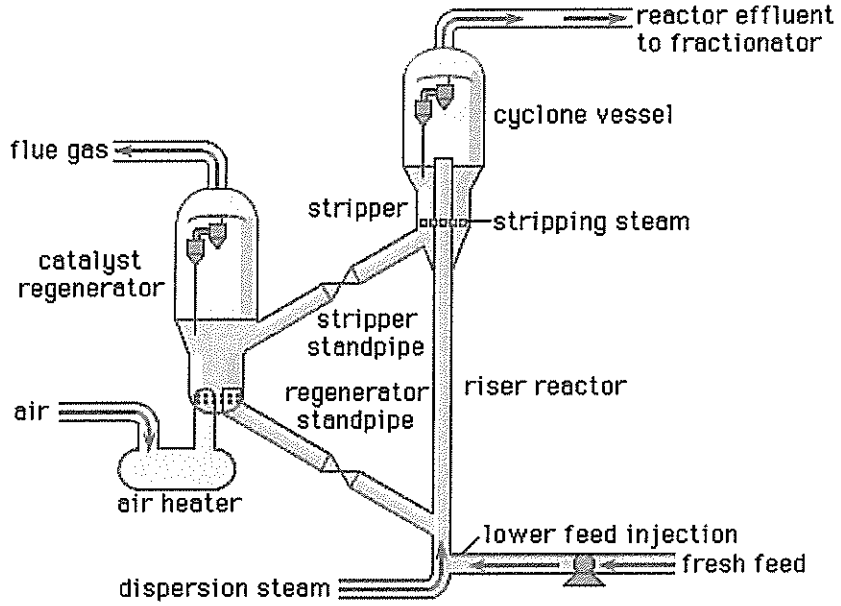
Appendix I



Fractional Distillation

[http://images.encarta.msn.com/xrefmedia/aencmed/targets/illus/ilt/T046185A.gif]

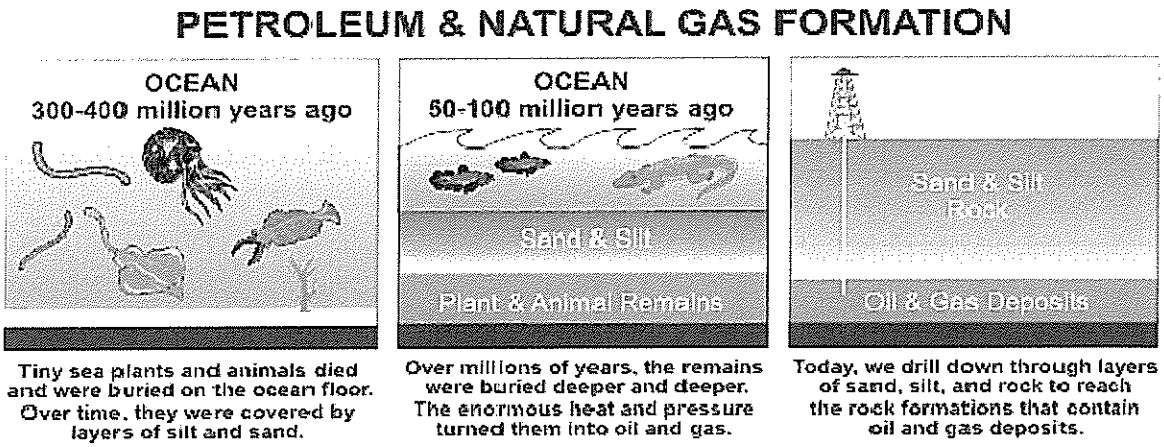
Appendix J



Fluid Catalytic Converter Unit
[http://cache.eb.com/eb/image?id=1558&rendTypeId=4]

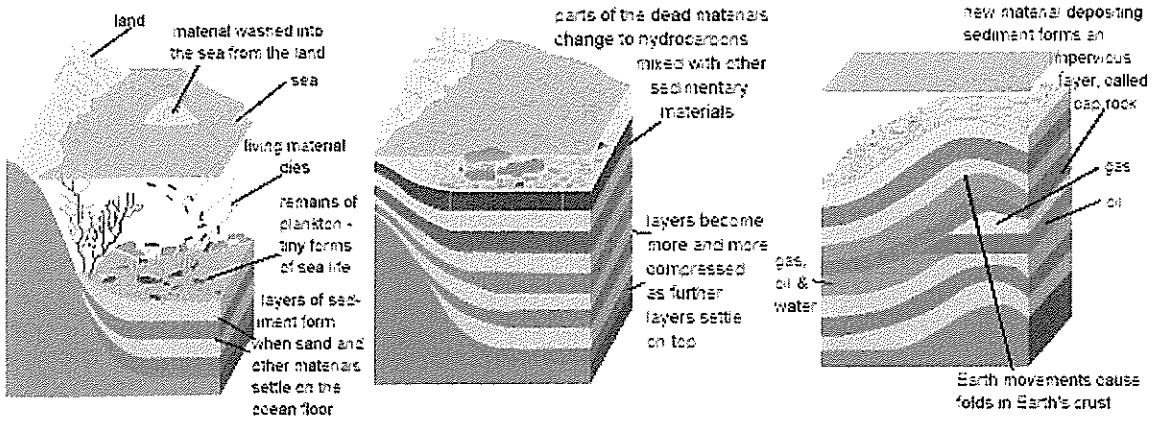
Fluid Catalytic Converter Unit
[http://www.fosterwheeler.it/fwisite/img/tec/fcc.jpg]

Appendix K



Crude oil formation

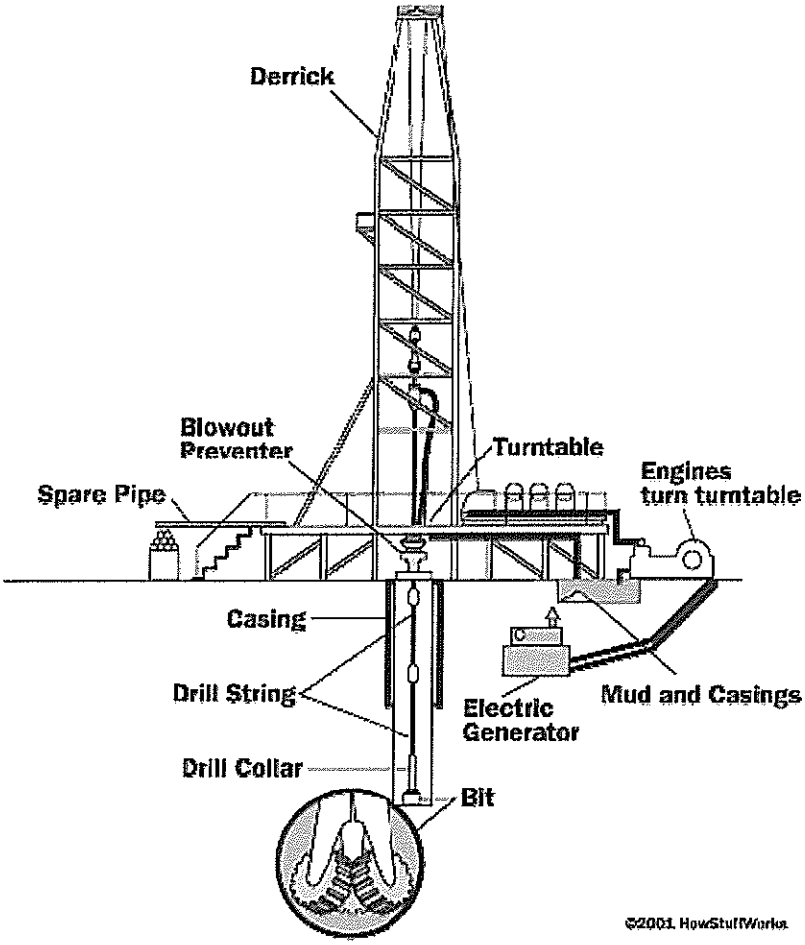
[http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/images/OILGASFORMATION.gif]



Crude Oil formation

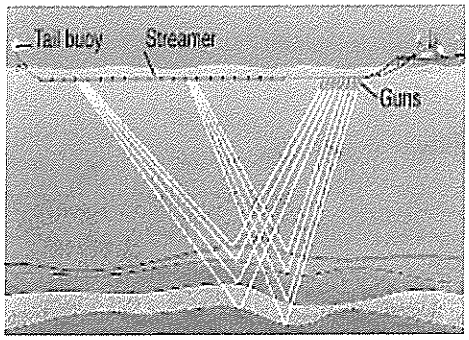
[http://www.columbia.edu/~ari2102/Oil%20Formation/firststageoilformation.bmp]
[http://www.columbia.edu/~ari2102/Oil%20Formation/secondstageoilformation.bmp]
[http://www.columbia.edu/~ari2102/Oil%20Formation/thirdstageoilformation.bmp]

Appendix L



Rotary Drilling Rig
[http://static.howstuffworks.com/gif/oil-drilling-derrick.gif]

Appendix M



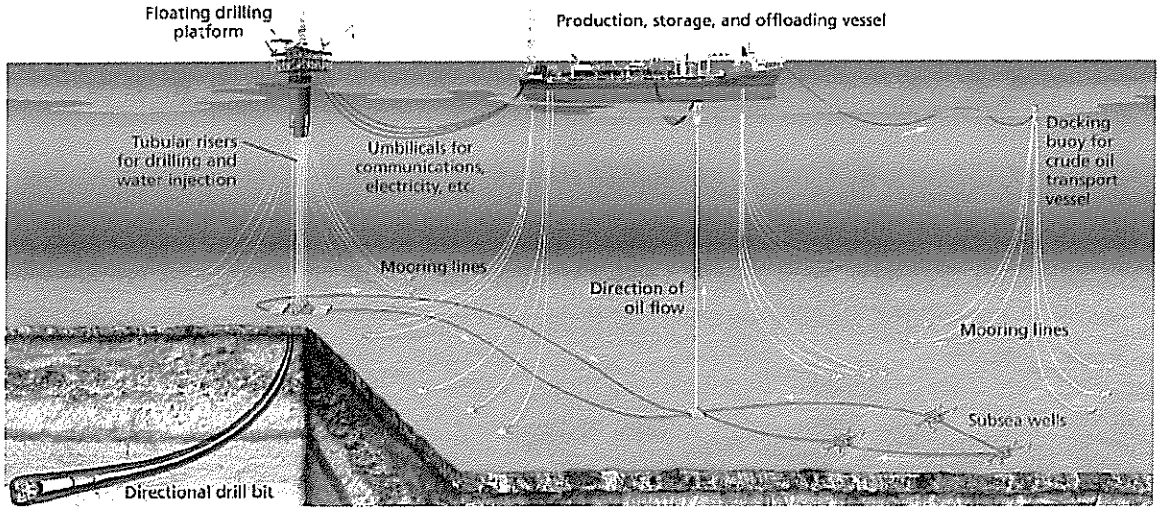
Seismic survey: sound wave propagation

Seismic Surveying
[http://www.tbs-sct.gc.ca/rma/dpr1/04-05/FO-PO/image/Seismic%20with%20text_eng.gif]

Appendix N

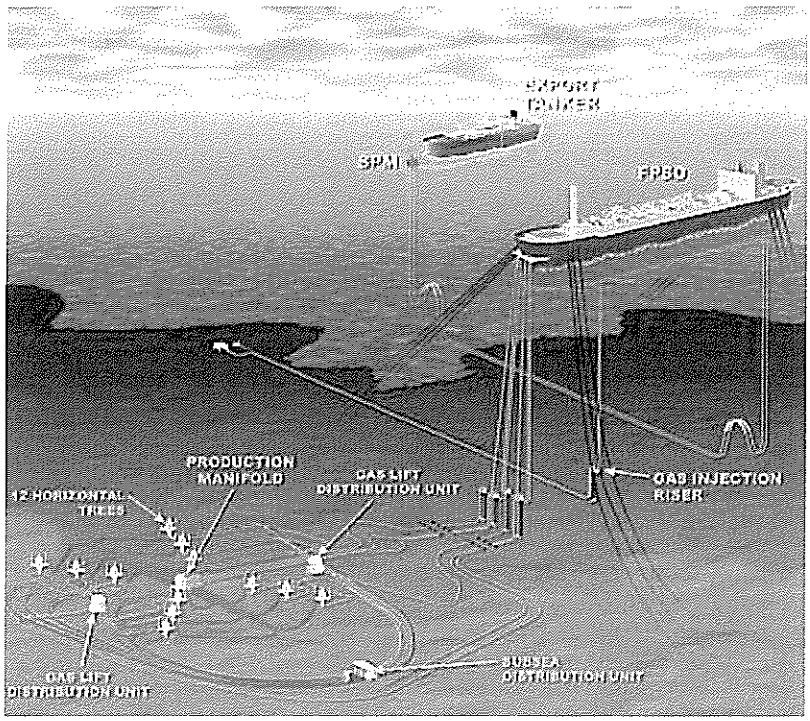
Rotary Drilling Rig
[http://www.naturalgas.org/images/rotary_drilling_rig.jpg]

Appendix O



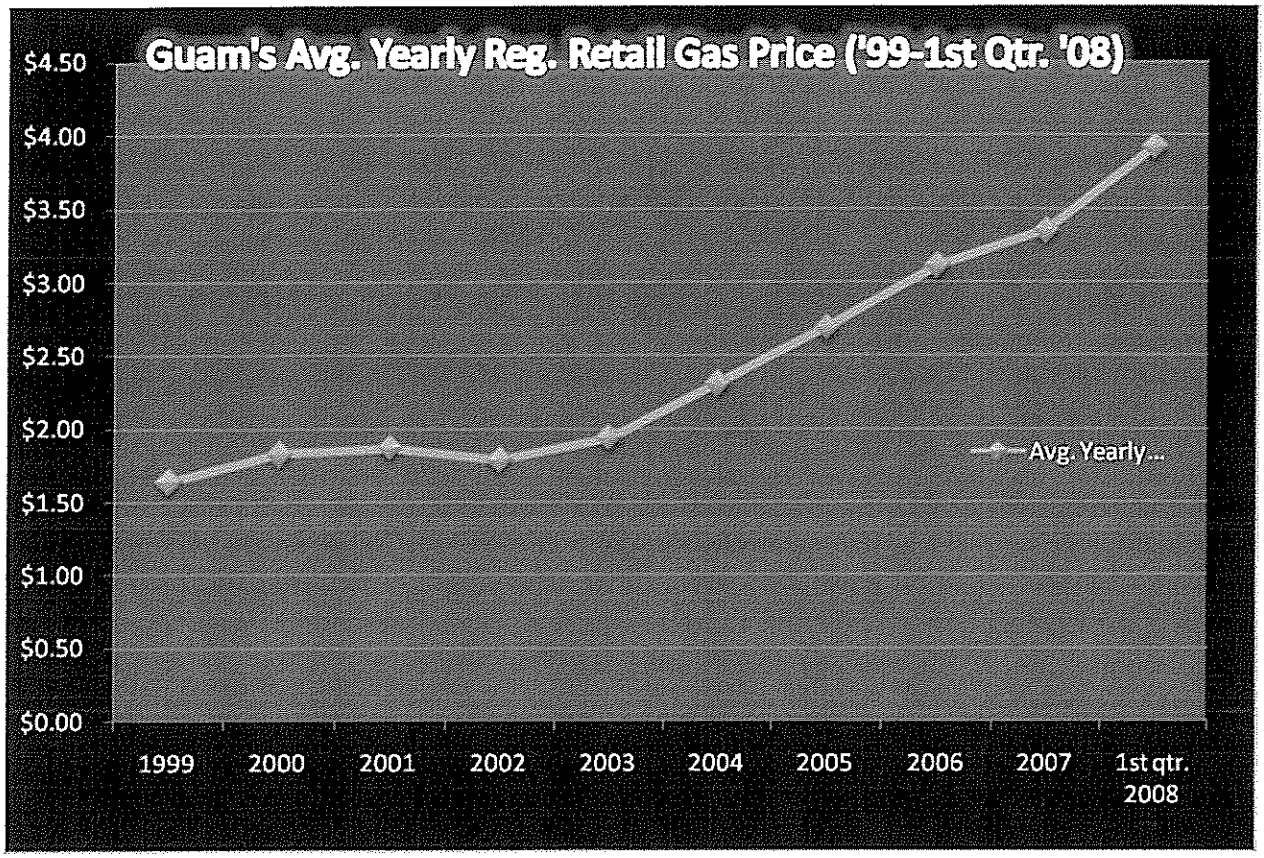
Drilling Platform
[http://www.ehponline.org/members/2002/110-1/drillingplatform.jpg]

Appendix P



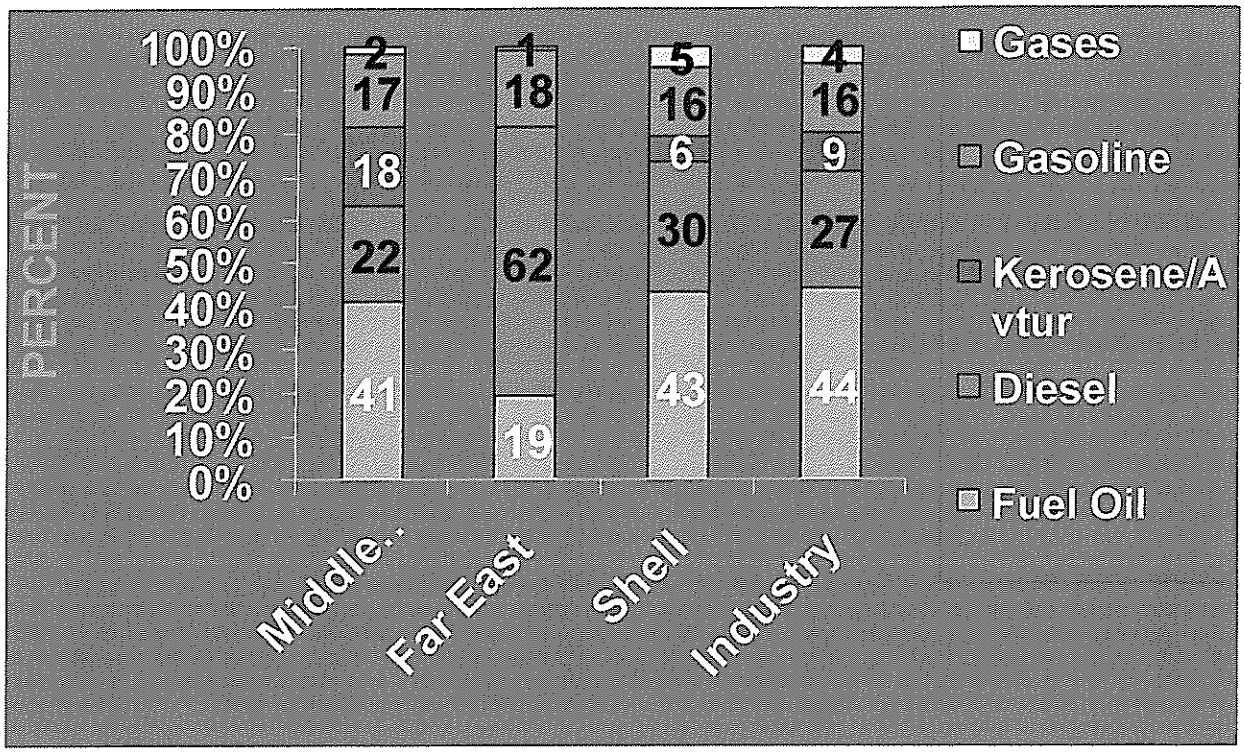
Offshore Production
[http://www.oil-price.net/pics/deep_oilfield.jpg]

Chart 1



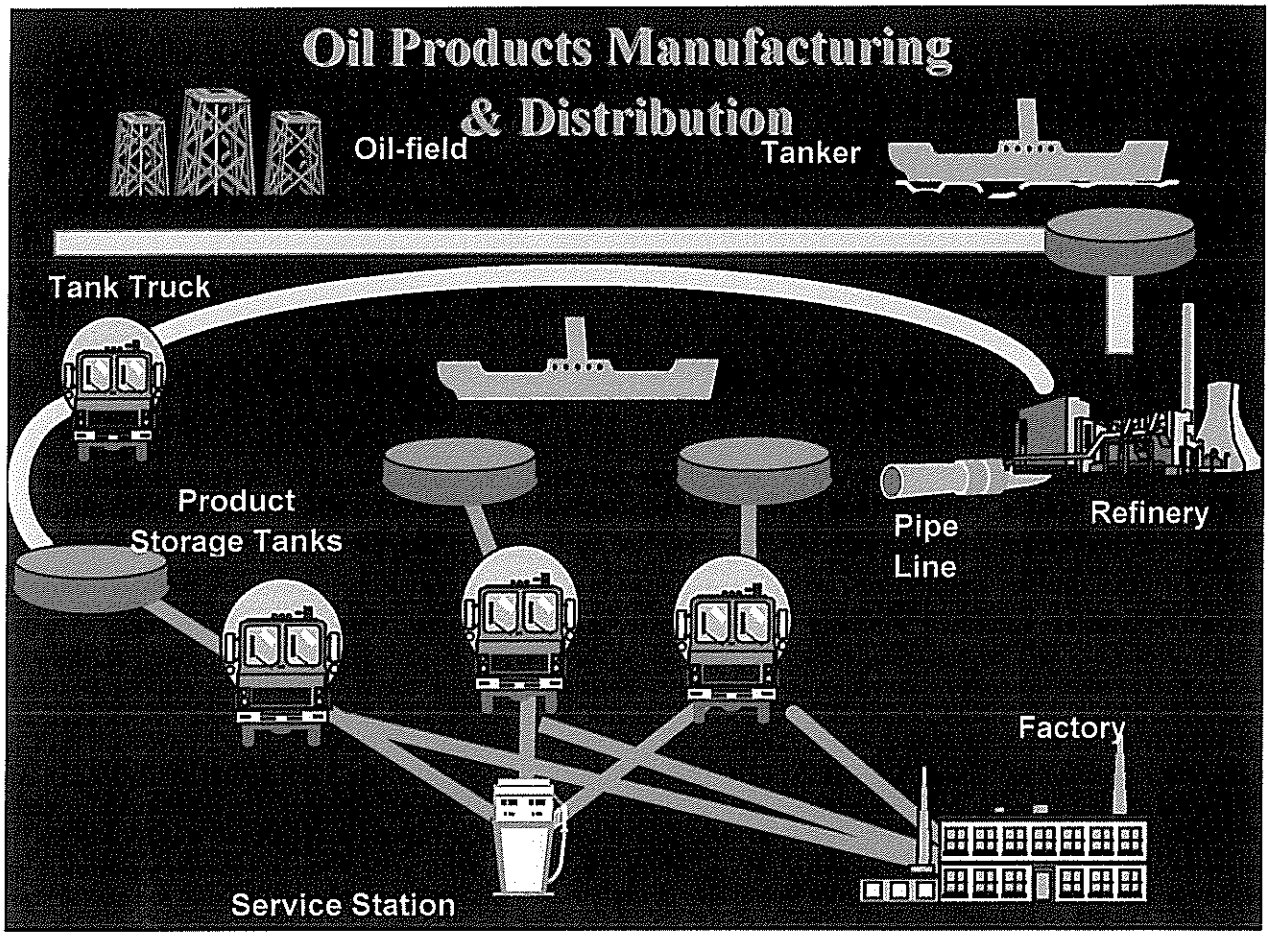
Average Yearly Regular Gas Price (1999-2008)
Information from Guam Energy Office

Chart 2



Crude Oil Yield
Perez, Jonathan Shell

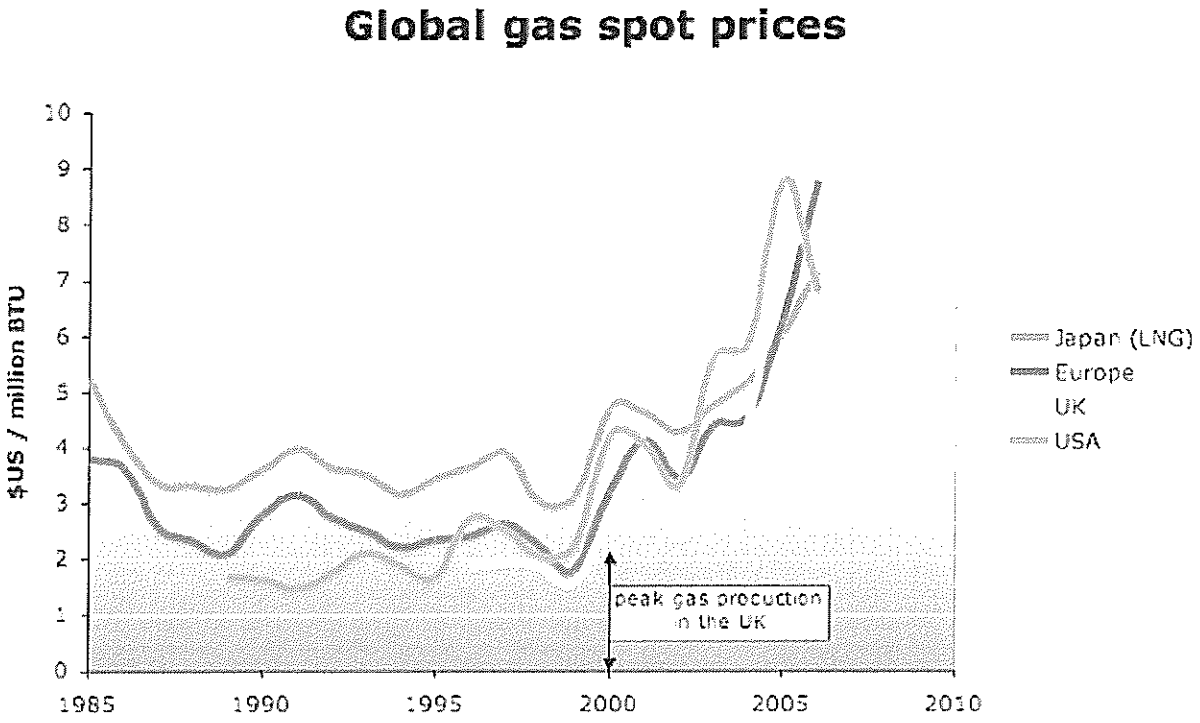
Chart 3



Gas Manufacturing and Distribution

[Perez, Jonathan, Shell]

Chart 4



Rise of Global Prices
"The Oil Drum"
http://www.theoildrum.com/files/global_gas_prices.png