Science 1101 - Petroleum and Peak Oil - Old Version

Posted by Gail the Actuary on January 29, 2008 - 11:00am
Topic: Supply/Production
Tags: corn ethanol, education, ethanol, oil, peak oil, refineries [list all tags]

Please Note: Based on feedback from readers, a revised version of this post has been prepared in two separate posts. See Part 1 and Part 2.

A university near where I live plans to add a short unit on "Petroleum and Peak Oil" to their Science 1101 course for freshman who are not science majors. They asked me to put together material for the unit - reading material, PowerPoint presentations, links to additional material, discussion questions, and suggested test questions. At this point, I am in the process of finalizing what will go into the reading material. I sent my contact a first draft, and he asked that I add sections on a number of other topics as well. This is my second draft, which includes the additional sections requested. I have not yet turned it in.

The focus is to a significant extent their choice. They wanted background information on a variety of petroleum-related topics, and not too much focus on precisely when peak oil would occur, or what dire results might happen. They recognize that corn ethanol is a very bad idea. The audience is expected to be 19 to 23 year olds, so the material needs to be suitable for this age group.

The university wants me to develop material others can use as well, so is willing to let me share what I develop with others. Thus, I don't see any problem with sharing this draft here. At this point, I can still make changes.

I would appreciate any input or comments TOD folks might have.

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1. What is petroleum?

Petroleum (also called oil) is a viscous liquid that is found beneath the earth’s surface. It is not found in large pools. Instead, it is generally trapped in the pores of sandstone or other porous rocks. It is often found with natural gas, which is formed under similar conditions.

Petroleum is not a single compound. Instead, it consists of a mixture of hydrocarbon chains of different lengths, ranging from about C_5H_{12} to $C_{42}H_{86}$. When petroleum is burned, the hydrocarbon chains plus oxygen are transformed into CO_2 (carbon dioxide) and H_2O (water), and energy is released. Carbon dioxide is one of the major gasses implicated in global warming.

2. What are the environmental impacts of petroleum?

One of the major impacts is its contribution to global warming. When petroleum is burned, carbon dioxide is formed.

If oil is compared to coal and to natural gas in terms of the amount of carbon dioxide produced per unit of energy, oil is in the middle. Oil produces 20% less carbon dioxide per unit of energy than coal. It produces 40% more carbon per unit of energy than natural gas. The problem is that we in the United States use nearly twice as much petroleum as coal. When the quantity of petroleum burned is considered, more carbon dioxide is produced from burning petroleum than coal.

Another environmental impact of petroleum is smog and other forms of air pollution. When petroleum products are burned as fuels, various chemicals are released from tailpipes. When these chemicals interact with sunlight, smog and various carcinogens are produced.

In some cases, local environmental damage can also be a problem. For example, development of the oil sands in Canada has had a very negative environmental impact. The extraction process requires a very large amount of fresh water. After the water is used, the polluted water is left in large lakes. http://www.commondreams.org/archive/2008/01/10/6304/

3. How was petroleum formed?

Petroleum was formed millions of years ago from the remains of small plants and animals that lived in seas or lakes. These plants and animals died and fell to the bottom of the sea. Gradually, layers of silt and sediment covered their remains, causing great heat and pressure to build up.

Under this heat and pressure, a chemical reaction took place, transforming the hydrogen and carbon from the decaying plants and animals into the mixture of hydrocarbons that we know as petroleum.

4. Is new petroleum now being formed?

Not in any measurable quantity. Once we use up the petroleum that was formed millions of years ago, it will be gone for good.

5. How is petroleum extracted from the ground?

Petroleum is generally extracted from the ground by drilling oil wells in areas where there is some reason to believe oil might be located. When oil is first found, it often comes from the ground very quickly, under great pressure. Gradually, the oil comes out more and more slowly. This happens partly because the oil pressure drops, and partly because the oil that is extracted from the ground tends to mixed with more and more water, as more oil is removed from the ground. Many US oil wells produce more than 99% water!

In some places, such as the Canadian oil sands, a very viscous form of oil is found. This is mined, rather than extracted using oil wells. Production of such oil tends to be very slow and expensive.

6. Is all of the oil in a given area removed by the use of oil wells?

No. As noted in Item 1, oil is not found in pools in the ground; instead it is trapped in the pores of porous rock such as sandstone or limestone. The rock is somewhat like a hard sponge, with the oil trapped inside. If only the oil that naturally seeps out is collected, only a small portion, typically 10% to 30% of the oil originally in place, can be extracted.

Various methods of enhanced oil recovery are used to increase the percentage of oil that can be removed. In some cases, water injection is used to increase the percentage of oil recovered.

Carbon dioxide or some other gas may be injected, to force some of the trapped oil out. In one newer process, microbes are used to break up the oil droplets into smaller pieces, so that they can more easily be removed. Even with these additional processes, 50% or more of the oil originally in place cannot be extracted by current methods.

(Water injection: http://en.wikipedia.org/wiki/Water_injection_(oil_production))

(Titan Microbal Method http://www.titanoilrecovery.com/)

7. Can an oil company produce a constant amount of oil in a given location?

No, it generally doesn't work this way. When a single oil well is drilled, production very often quickly reaches a peak, then tapers off over a several-year period, as oil pressure drops and the amount of water produced increases.

When we look at production from all of the wells in a given geographic area, production generally tends to rise for several years, as more and more oil wells are drilled. One by one, wells begin to decline, and new wells are drilled. Eventually, there are not enough new places to drill additional wells, and overall production starts to decline. US oil production for the 48 states excluding Alaska and Hawaii reached its peak in 1970.

Once energy companies realized that production was declining in the US 48 states, they looked for new locations where oil might be produced. Production began in Alaska, once a pipeline was built. Production in Alaska has been declining since 1988.

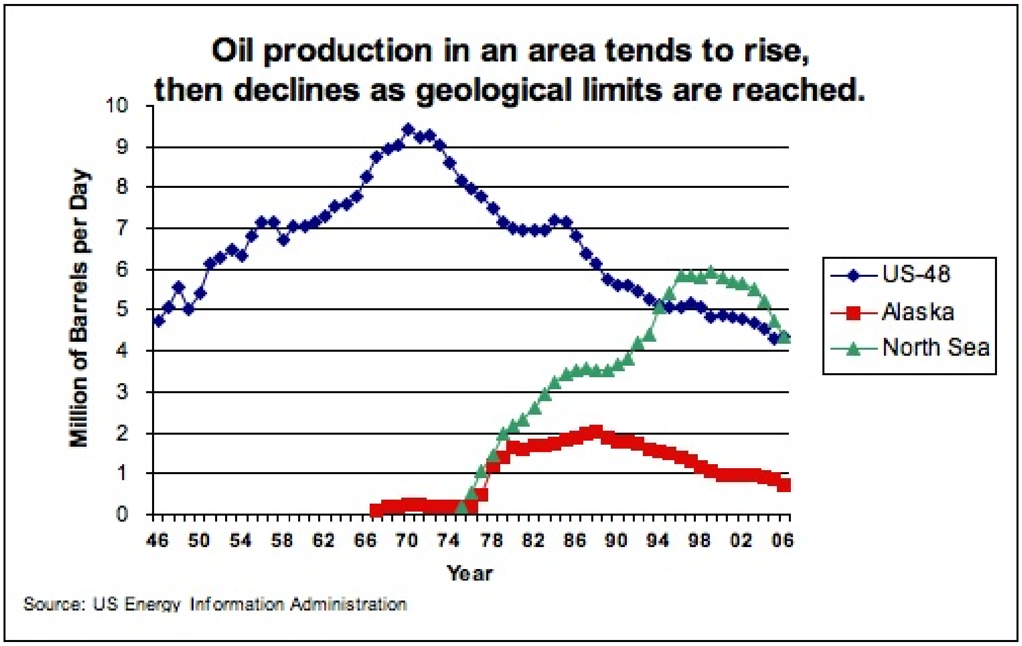

Figure 1

Oil production was also begun in the North Sea, near Norway and Great Britain. North Sea oil production has been declining since 1999. All of these declines have taken place in spite of new technology and improvements in oil recovery methods.

Oil is produced in many other parts of the world as well, but production in many of these locations is starting to decline as well. At this point, much of the world's "easy to produce" oil has been removed. New oil production tends to be in difficult areas, like deep-sea locations.

8. Will world oil production reach a peak and begin to decline? If so, when?

Since oil is a finite resource, we know that production must eventually decline. There is considerable disagreement as to when this decline in production will occur.

The US General Accountability Office (GAO) released a report in March 2007 titled, "Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production." This report indicates that the peak and decline is likely to occur sometime between now and 2040. The United States Association for the Study of Peak Oil indicates that the peak and decline is expected to occur prior to 2015.

Even oil companies are beginning to talk about the likely shortfall in future production, if not peak oil itself. Shell Oil says, "After 2015, easily accessible supplies of oil and gas probably will no longer keep up with demand."

(GAO Report: http://www.gao.gov/new.items/d07283.pdf)

(Shell Oil statement: http://www.shell.com/home/content/aboutshell-en/our_strategy/shell_globa...)

(Canadian Business article: http://www.canadianbusiness.com/columnists/jeff_sanford/article.jsp?cont...)

9. Does the date of the peak matter?

We have already reached the point where the amount of oil that people would like to use exceeds the amount being produced. Because of this, we need to find ways to conserve, and to find alternative energy sources. The actions we need to take are pretty much the same, whether the peak in world oil production is now, or in 2040.

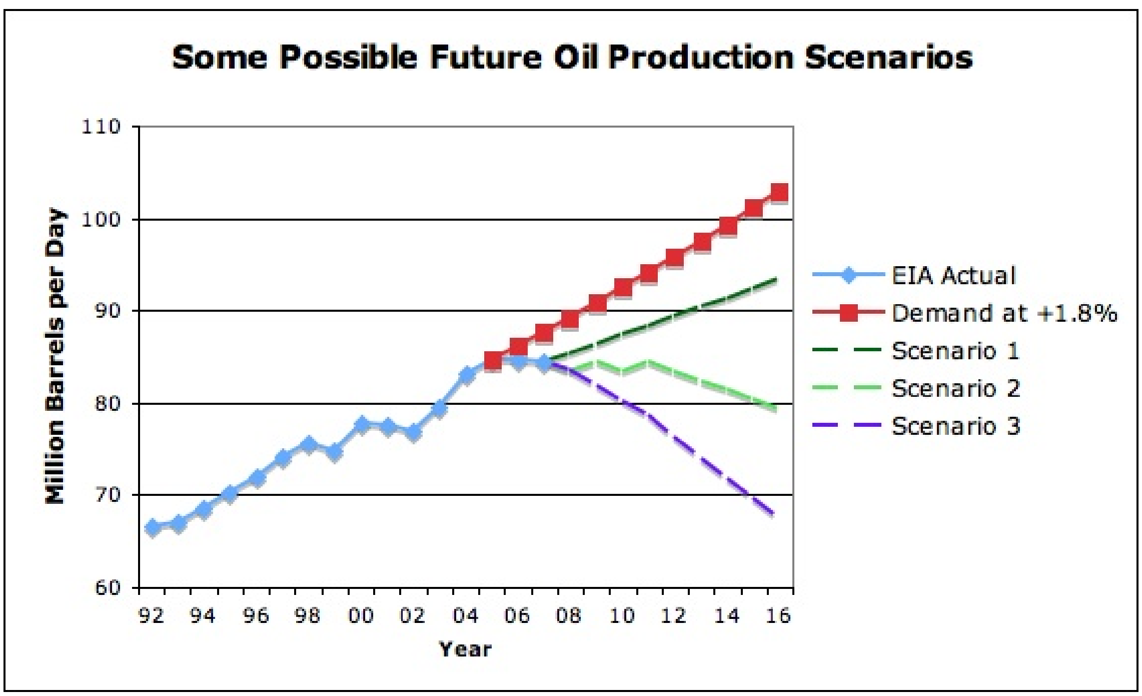

Figure 2

In Figure 2, the "Demand at +1.8%" line gives an idea of how much oil the world would like to use, if it is actually available, at a reasonable (2005) price. It assumes 1.8% per year growth. Scenarios 1, 2, and 3, give three (of many) possible directions future oil production may follow. Even if a fairly optimistic scenario like Scenario 1 occurs, there is likely to be a significant gap between demand and supply.

10. Aren't we continuing to discover more and more oil every year?

We are continuing to discover oil, but the quantity of oil discovered is lower now than it was 50 years ago, and much lower than the amount of oil we are now using. A graph of oil discoveries by ten-year periods is as shown in Figure 3:

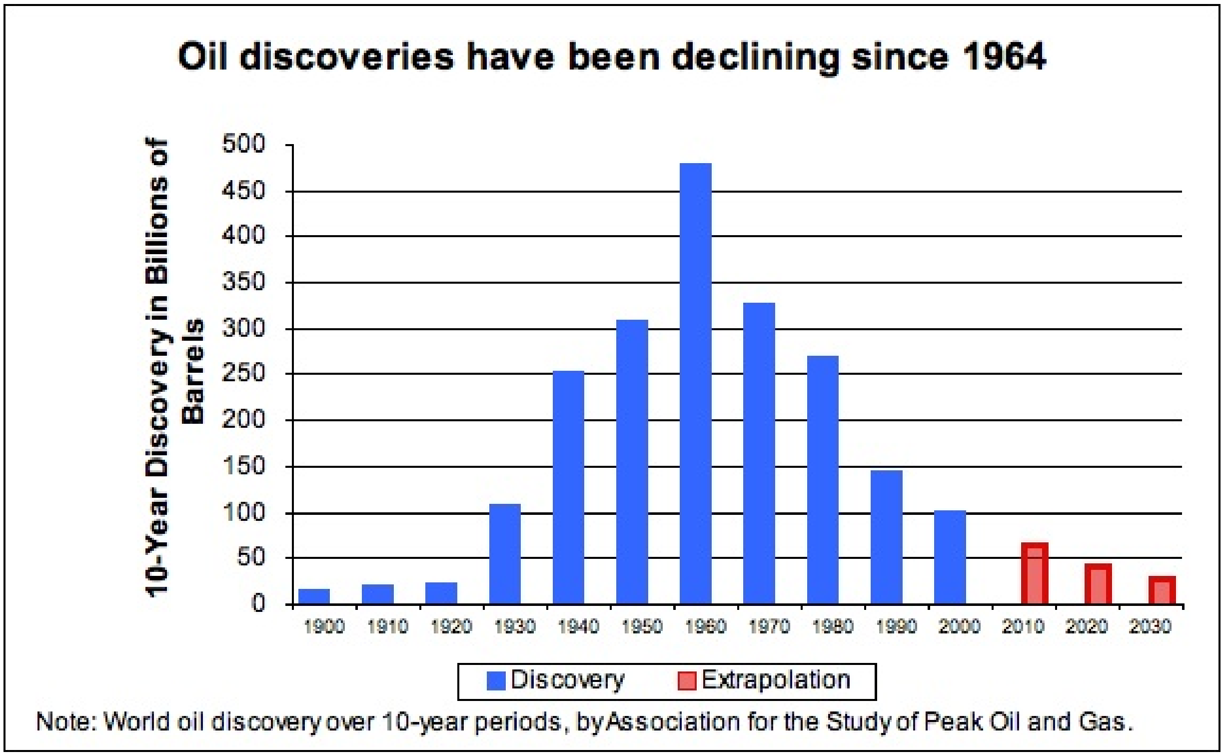

Figure 3

We often read in the news about finding new fields, but these fields tend to be smaller and harder to reach than those discovered in the past. We are now so concerned about finding oil that even small discoveries are reported as news.

Figure 3 does not include oils that are not liquids, like the Canadian oil sands. There are large quantities of these, but extraction is extremely slow. It is doubtful that they will ever become a significant share of world oil production.

11. Why don't we have better information on when world oil production will begin to decline?

In 1959, M. King Hubbert correctly forecast that oil production for the United States was likely to reach a peak and decline about 1970. Many people, using a number of methods, have developed forecasts that indicate that world production is likely to begin to decline in the not too distant future. We cannot be certain of the exact timing, however, for several reasons:

(a) The United States, Europe, and Australia are now well past the peaks of their oil production. The biggest producers are now Russia and the Middle East. The governments of these countries are very secretive about the true state their oil fields.

(b) There is little relation between published "reserves" and the amount of oil that can actually be pulled out of the ground in a given year. It is the latter we are really interested in.

(c) The amount of oil production depends to a significant extent on the amount of resources (trained engineers, drilling rigs, funding for research and development) that are available. These may change.

(d) We can't know what new technology will be developed and how helpful it will be in increasing future production. Current production methods leave a considerable amount of oil in the ground. There is a possibility that new methods will provide greater recovery in the future.

12. What is petroleum used for?

Figure 4 shows what petroleum is used for. The biggest slice is gasoline, with 46%.

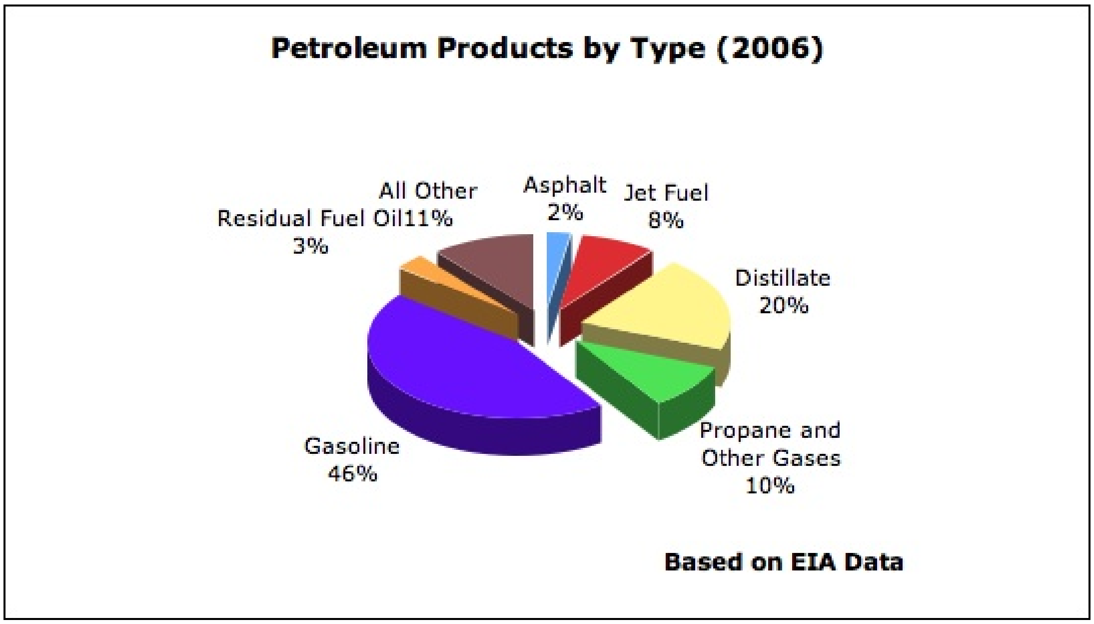

Figure 4

The next biggest slice is "distillate", with 20%. Distillate includes diesel fuel and home heating oil (used primarily in the Northeast). Between gasoline, diesel fuel, and jet fuel, petroleum provides the vast majority of the transportation fuel used in the United States. It also provides asphalt for our roads.

The "All Other" category is quite small on the graph, but includes most of the chemical uses for petroleum. Products made using petroleum as a feedstock include plastics, synthetic fabrics, dyes, pharmaceutical drugs, detergents, insecticides and herbicides, and many other products we use every day.

In some parts of the world, petroleum is used to produce electricity. It is not generally used for electricity-generation in the United States, however.

13. How is petroleum processed to obtain its major products?

Petroleum is sent to a refinery, where it is processed to remove impurities and to separate it into its component parts. As we noted earlier, petroleum is a mixture of different hydrocarbons ranging from about C_5H_{12} to $C_{42}H_{86}$. These hydrocarbons have different properties, including different boiling points and different viscosities. Very short chains, containing 1 to 4 carbon molecules, are gasses at room temperature. Chains with 5 to 10 carbon molecules are thin liquids that boil at low temperatures. The longest chains are asphalt or bitumen. Asphalt is very viscous, and has a very high boiling point.

During refining, a process called *fractional distillation* is used to separate out the mixture into components. In this process, petroleum is heated to a vapor, and then allowed to condense in a tower containing trays at different levels. Because the shorter hydrocarbon chains boil at lower temperatures than longer chains, this process can be used to separate petroleum into its component parts. The lighter the fraction, (that is, the fewer carbon molecules in the chain), the higher up it condenses.

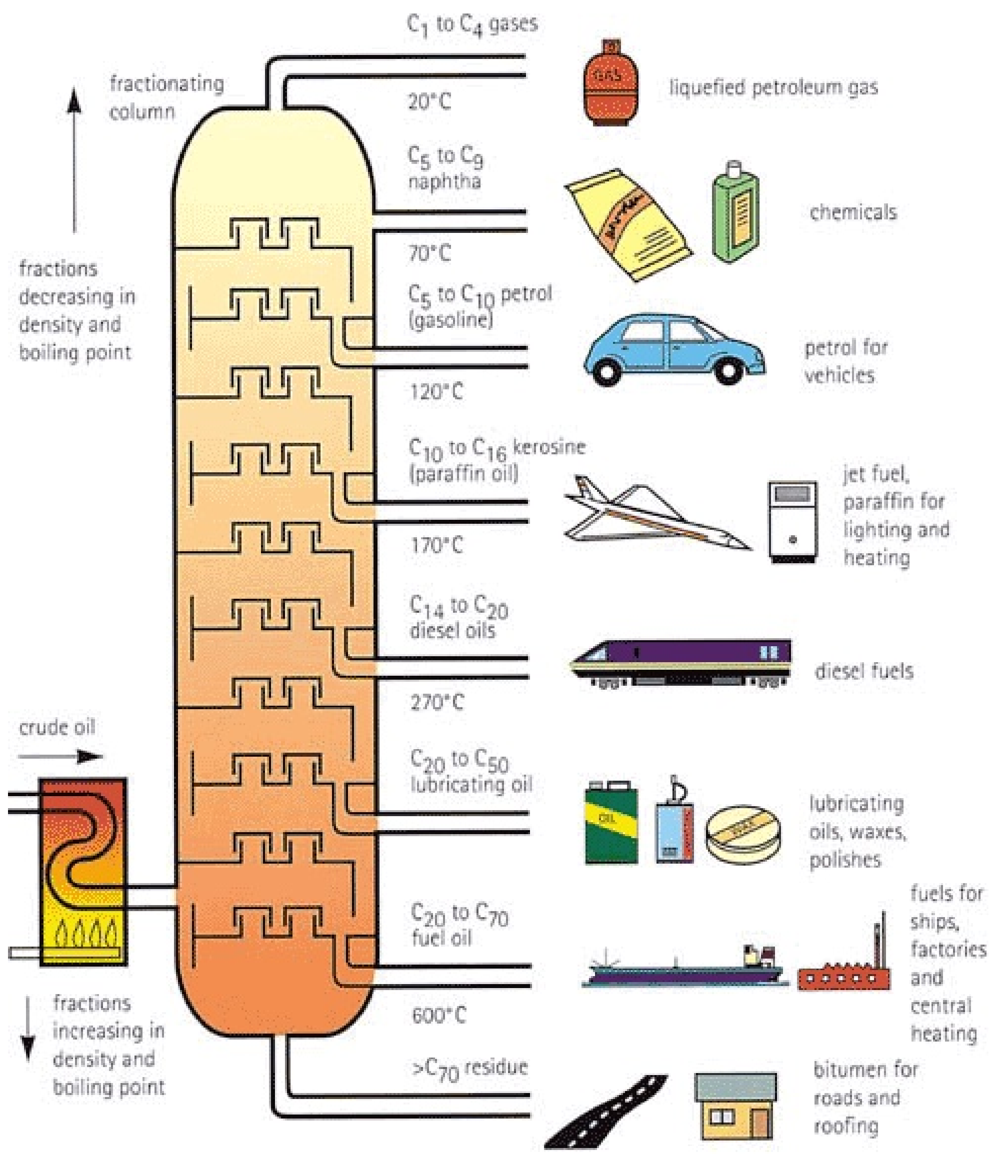

Figure 5. Fractional Distillation (Diagram by The Institute of Petroleum, UK)

For further discussion see “How Oil Refining Works” on HowStuffWorks.com (http://science.howstuffworks.com/oil-refining.htm)

14. Is petroleum from different locations the same?

No. Some petroleum is "light" – that is, comprised mostly of the shorter chain hydrocarbons. Other petroleum is "heavy" – that is comprised mostly of longer chain hydrocarbons. Some is even "very heavy". Oil also differs in the amount of impurities. The highest quality (and highest priced) crude oil is light oil, with few impurities. The lowest priced crude oil is heavy oil, with many impurities.

The reason that light oil is prized is because when fractional distillation is used, it yields a high proportion of gasoline and diesel fuel, and relatively little asphalt and other lower priced products. When fractional distillation is used on heavy oil, it tends to yield a high a proportion of asphalt and other low priced products. A process called "cracking" can be used to break very long molecules into shorter, more commercially valuable molecules, but this process is expensive, and requires specialized equipment.

The amount and types of impurities in crude oil is also important in determining the selling price of crude oil. Special processes, available only in certain refineries, may be needed to remove certain types of impurities. In some cases, it is necessary to build a refinery especially for oil from a particular location, so as to have the proper equipment to remove the impurities from the oil.

15. How is oil transported from place to place?

When crude oil is found in a location, it must be transported to a refinery for processing. If the crude oil is from overseas, it is generally transported by an "oil tanker" (type of ship) to one of the major US ports. It is then transported from the US port to the refinery by pipeline. If crude oil is shipped from within the United States or Canada, it is generally sent by pipeline to the refinery.

Once the oil is refined, the refined products are again shipped by pipeline to a location near where they will be used. Trucks are generally used for transportation to the final customer.

The one exception to this process occurs for gasoline with ethanol. The gasoline base is shipped by pipeline, but ethanol cannot be shipped by pipeline, because it tends to absorb water. Ethanol must therefore be shipped by other means (railroad, barge, and /or truck) to a location near where the gasoline will be sold. There, ethanol is blended with the appropriate gasoline base to make gasoline. After it has been blended with the base, it is shipped by truck to the retail location where it is sold.

16. What determines the price of gasoline?

According to the US Energy Information Administration, the components of the cost of a gallon of gasoline are as follows:

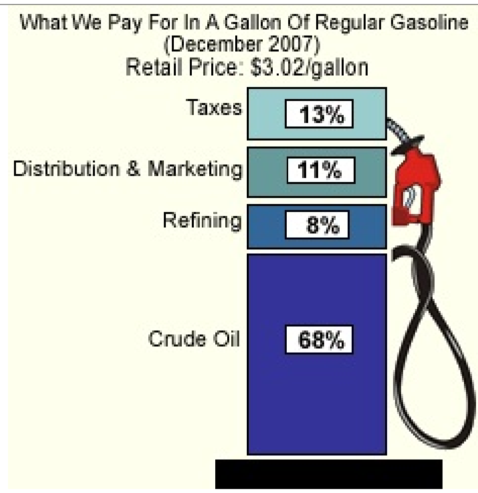

Figure 6

The biggest component is the cost of crude oil. As the price of crude oil rises, the price of gasoline can be expected to rise. Operating refineries amounts to 8% of the cost. Distribution and marketing would include the cost of maintaining all of the distribution pipelines, plus the cost of the retail facility, and the cost of marketing. Taxes would include state and local taxes.

This diagram above does not really discuss the impact of ethanol on gasoline price. Ethanol tends to raise the price of gasoline, particularly in summer. The problem is that when ethanol is added to gasoline, it makes the gasoline evaporate at lower temperatures, causing smog when outdoor temperatures are warm. To counteract this, it is necessary for refiners to take out that part of the gasoline that evaporates most easily – that is, the hydrocarbon chains in the gasoline mix with 4 and 5 carbon atoms. This still leaves hydrocarbons with 6 to 10 carbon atoms in the mix. When the chains with 4 and 5 carbons are eliminated from the gasoline mix, the total amount of gasoline available in the summer is lower. The resulting scarcity of gasoline during summer months tends to drive the price of gasoline up. (See http://www.eia.doe.gov/oiaf/servicerpt/fuel/mtbe.html)

We also pay for the ethanol included in gasoline in other ways. First, ethanol production is subsidized (51 cents a gallon nationally, plus many local subsidies), so we pay higher taxes to cover the ethanol subsidies.

We also pay for ethanol through higher food prices. A huge amount of corn (more than 25% of the 2007 US corn crop) is being used for ethanol. This means that land that would be planted for other food crops is being planted for corn, driving up the cost of the other crops. The cost of corn is rising because of the demand of corn for ethanol. This in turn raises the prices for meat and milk, since many animals eat corn.

17. If demand for petroleum products continues to be very high, but supply falls short, what is the likely impact on prices of petroleum products, such as gasoline?

Prices can be expected to continue to rise. The increase in prices is likely to be especially great, if world oil production begins to decline.

Even if oil production does not actually decline, the fact that there is likely to be a growing gap between the amount produced and the amount people want to buy means that prices for petroleum products of all types can be expected to continue to rise in the future. If oil supply should actually fall, there is a possibility that rationing may be needed, so as to have adequate supplies for farmers, the military, and essential services.

18. How certain are future petroleum imports?

Oil imports comprise about two-thirds of the United States petroleum use, but we are not very certain about how much we will be able to import in the future. Oil exporting countries tell us very little about what their true future oil production is expected to be. Reserve estimates are published, but are widely believed to be inaccurate. Furthermore, what we are interested is the amount of oil that will be *exported*. If there is a shortfall, the exporter may meet its own needs first, reducing the amount available for export.

There are other issues that also affect imports. If there is civil unrest in an area, oil exports may be stopped. Another concern is possible drop in the value of the dollar, because of difficulties within the financial system, or because of balance of payment problems. If value of the dollar should decline, oil will be much more expensive, so it will be difficult to buy as much.

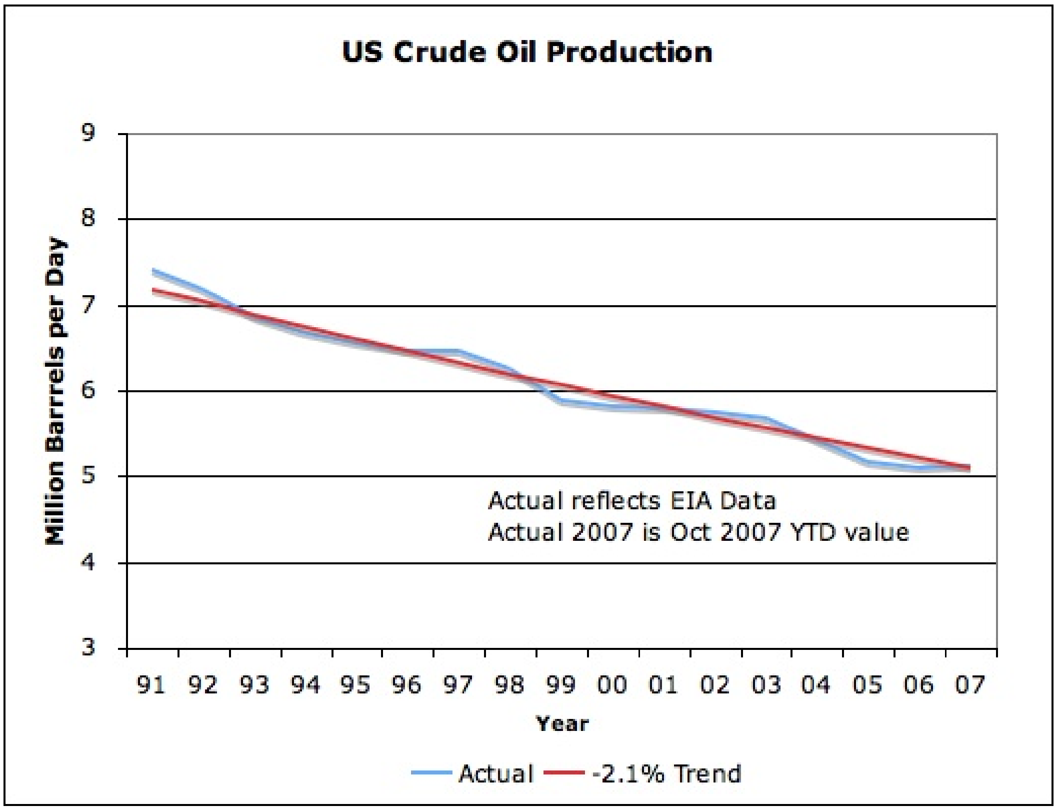

Figure 7

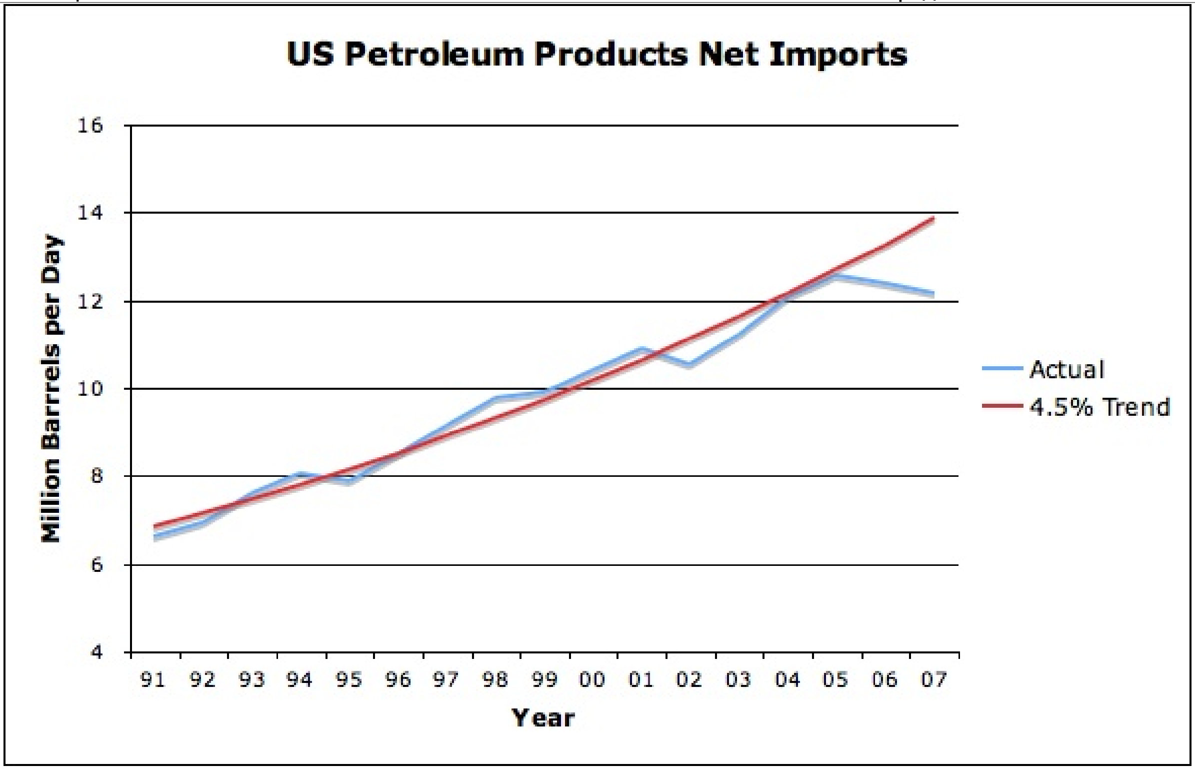

Figure 8

Note that net petroleum imports have declined in the last two years. It is likely that this is related to the fact that worldwide oil production has been flat since 2005. (See Figure 2). Flat world production and lower imports are also closely related to the run-up in price of oil products, such as gasoline, during this period.

19. Are there any good solutions to the expected shortfall in petroleum production in future years?

At this point, we are still looking for good solutions. It seems clear that conservation has to be a major part of any solution.

Biofuel, such as corn-based ethanol and biodiesel from canola beans, is one approach that is being tried. There are many problems with the current generation of biofuels. Some of these include:

(a) A very large amount of farmland is required to produce a very small amount of ethanol or biodiesel. It is not possible to scale the process up to more than 5% to 10% of our gasoline use, and possibly even less of our diesel use.

(b) The use of farmland for biofuel production tends to drive up the cost of food.

(c) When corn is used for ethanol, it takes nearly as much energy to produce the ethanol as is obtained in the end product, so we are mostly recycling other scarce fuels. A huge amount of water is also required, and there can be issues with topsoil depletion.

(d) Corn ethanol does not seem to be helpful from a global warming perspective. Some studies show a slight (10% to 15%) savings in global warming gasses relative to gasoline; one recent study indicates that corn ethanol may be worse than gasoline because the nitrogen used in fertilizer tends to react with the oxygen to form nitrous oxide, a greenhouse gas with 300 times the global warming impact of carbon dioxide. (Regarding recent study, see http://www.rsc.org/chemistryworld/News/2007/September/21090701.asp ; for the 10% to 15% estimate see http://rael.berkeley.edu/EBAMM/FarrellEthanolScience012706.pdf)

(e) The impact of ethanol (from any source) on air quality is questionable at best. One study by researchers at Stanford University indicates that ethanol has a more negative impact on air quality than gasoline. (See http://news-service.stanford.edu/news/2007/april18/ethanol-041807.html

It is possible that cellulosic ethanol, made from non-food bio-products such as wood, switchgrass, and corn stalks, can be a solution. At this point, we do not have an economic way of making cellulosic ethanol. Also, even if this approach can be perfected, it is not expected to produce more than 20% of our total petroleum needs.

There are other biofuels that may be helpful, but none is a good solution to date. Biodiesel can be made from left over vegetable oil, but it is difficult to produce very much biofuel this way. Researchers are looking at the possibility of using algae to produce biodiesel, but have not figured out an economic way of doing this. Biofuel of various kinds (ethanol from sugar cane; biodiesel from fruits of various trees) is available from overseas in relatively small quantities. Very often, forests have been cut down to make room for these biofuels, making the environmental impact quite negative. Sugar cane ethanol is probably better than most, but there are still human rights issues with respect to the workers producing the ethanol.

(MIT Cellulosic Ethanol article: http://www.technologyreview.com/Energy/19842/ Free registration required)

(One company claiming progress on making low-priced cellulosic ethanol: http://www.coskataenergy.com/process.html)

(Congressional Research Report for Congress “Ethanol and Biofuels: Agriculture, Infrasturcture, and Market Constraints Related to Expanded Production, 3/16/2007 http://collinpeterson.house.gov/PDF/ethanol.pdf)

Another possible solution is coal-to-liquid fuels. A process was developed many years ago that allows coal to be converted to a liquid substitute for some petroleum products. The major problem with this approach is that it generates a huge amount of carbon dioxide, which contributes to global warming. This approach is also difficult to scale up quickly.

Natural gas supplies are not sufficient in North America to substitute natural gas for oil. There are not sufficient supplies of liquefied natural gas from overseas available, either.

20. Why is there so much support for corn-based ethanol, if it seems to have so many problems?

One of the biggest reasons for corn-based ethanol’s support is that the problems with corn-based ethanol were not really understood when production first began. It is a little like introducing a new medicine, and then doing testing after the fact. Once the testing starts, researchers find a whole set of problems that were never anticipated by the well-meaning early supporters of the product.

Some other reasons for corn-ethanol’s support, despite its problems:

• Ethanol's role as an “oxygenate”. An oxygenate is an additive for gasoline which increases the “octane” (see http://auto.howstuffworks.com/question90.htm) of the gasoline. It also reduces the amount of unburned hydrocarbons and carbon monoxide in the exhaust. Gasoline manufacturers began using ethanol as an oxygenate when previous oxygenates (first lead, then MTBE) proved to be unsatisfactory. At this point, it is not clear whether an oxygenate is really needed in gasoline, because modern engines burn fuel cleanly. http://www.foxnews.com/story/0,2933,104259,00.html

• Corn-based ethanol may work as a bridge fuel, until cellulosic ethanol can be perfected. If cellulosic ethanol can be perfected, it would not put as much pressure on food prices because it would be created from wood and other not-food products. It would probably also produce fewer global warming gasses.

• The use of corn ethanol raises the income of farmers, and has benefits for investors in corn ethanol refineries. The drawbacks, in terms of higher food prices and higher taxes for others, are not as obvious.

• The use of corn ethanol is popular with voters. It makes politicians look like they are doing something about oil shortages. It also makes people think that politicians are doing something to help the environment. People do not realize that the petroleum savings from the use of corn ethanol are likely to be small, and likely to be largely offset by the need for greater imports of natural gas and fertilizer, which are also in short supply. Corn ethanol was at one time believed to have environmental benefits, but these are seriously in doubt based on recent studies.

• Auto manufacturers support ethanol use. Current laws permit auto manufacturers to build more gas guzzling vehicles and still stay within fuel economy standards, if some of the gas-guzzlers are "flex-fuel" vehicles that can use 85% ethanol when it is available. This is basically a loophole that makes no sense.

21. How about solutions such as wind turbines, solar voltaic panels, and battery operated cars?

These all can be useful, but they don't directly solve our need for petroleum. We have a variety of energy issues, and wind turbines and solar voltaic panels really relate to our need for better sources of *electricity*. This is a different issue than our need for a replacement for petroleum, but also important.

Battery-operated cars are a worthwhile idea, but are at best a long-term solution, since it will take many years to replace the cars currently on the road. The use of battery-operated cars is also very limited in scope – we need to keep semi-trucks, airplanes, and farm equipment of all types operating. We also need a product for paving our roads besides asphalt. If we cannot find a replacement for petroleum, we will need to find alternate approaches for a wide range of petroleum uses.

22. What implications do our likely shortfall in future petroleum production have for career opportunities?

Careers in fields that are very petroleum-dependent may not be good choices. For example, there will likely be fewer airline pilots in 2040 than there are today.

If there is less petroleum, people are likely to be interested in having stores nearby that they can walk to. Thus, there may be an opportunity for starting a small store in your own neighborhood, or developing a neighborhood clinic.

Recycled products, especially those using petroleum inputs, are also likely to become more important. There may be careers in buying and selling these products.

There is clearly a need for more scientist and engineers in many energy-related fields. We need to find better ways to extract the oil that is available, and we need to develop more fuel-efficient vehicles. We need to find more and better petroleum alternatives, and to find ways to scale up these alternatives to the quantities needed as replacements for petroleum products.

23. What can we do to try to compensate for this expected shortfall in petroleum products?

These are several ideas:

(a) When buying a car, purchase the smallest, most fuel-efficient model you can find.

(b) Consider sharing rides with someone else who is commuting in the same general direction, or take public transportation.

(c) Make greater use of work-at-home programs and distance learning programs. Or live in a dorm.

(d) Move closer to work or school.

(e) When distances are short, walk or ride a bicycle, rather than drive.

(f) Use recycling, especially for petroleum-based products like plastic. Other recycling is also helpful from a general energy-saving perspective, but not necessarily from a petroleum-saving perspective.

(g) Avoid fruits and vegetables that have been flown to the United States from around the world. These tend to be quite expensive.

(h) Reduce trips taken to distant locations, whether by air or automobile.

One idea which looks at the shortfall a different way is to reduce meat consumption, by eating smaller portions of meat, or by substituting beans for meat in some meals. We are currently using biofuels as a substitute for petroleum, and this puts huge pressure on the food supply. By eating less meat, a person can help reduce the pressure on the food supply.

Animals eat several times as many calories in grain products as they produce in meat calories. By eating less meat, fewer acres of grains need to be planted to meet our food needs. We also reduce production of global warming gasses, because animals, particularly cows, are big contributors to these gasses.

For further reading

A number of links are given in the reading material. In addition, some websites that may be of interest are

TheOilDrum.com - Discussion about energy and our future, including peak oil. Many articles written for the site, plus news items related to energy, and discussion about the various items.

EnergyBulletin.net- Peak oil related news items. No discussion.

Association for the Study of Peak Oil and Gas - USA http://www.aspo-usa.com/
Has a good weekly newsletter, and an annual conference

Educational website about oil and gas, how it is formed, and production ins and outs http://www.ukooa.co.uk/education/storyofoil/index.cfm

Myths of Biofuels - Talk by David Fridley - Free video for download
http://www.sfbayoil.org/sfoa/myths/index.html

Paper by M. King Hubbert, who correctly forecast in 1959 that US oil production would reach a peak in 1970 and begin declining thereafter
http://www.hubbertpeak.com/hubbert/1956/1956.pdf

Peaking of World Oil Production: Impacts, Mitigation, and Risk Management by Robert Hirsch, Roger Bezdek, and Robert Wendling - Landmark study prepared for the US Department of Energy in 2005. Very readable.
http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf