The World's Diminishing Oil

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Introduction

The amount of oil that can be recovered from the earth is finite. For over a century we have been finding pockets of this fossil fuel, pumping them dry and moving on to new finds. As this process has continued, the new sources have become fewer, smaller, more difficult to find and more expensive to make productive. Many analysts believe that world production of oil is reaching its zenith, called peak oil. The timing of peak oil is dependent on known petroleum reserves and on the health of the economy, since oil availability is a balance between supply and demand. One estimate of when world petroleum production would peak is on or before 2023, with rapid decline in production expected after the peak. The United States economy has become dependent on petroleum as virtually its only liquid fuel source, so a decrease in available oil will have wide effects. This study is designed to outline how we have arrived at this point, some expected effects of a lack of petroleum and possible new technologies that can help us to move towards a post-oil economy.

Since the Industrial Revolution began, human civilization has been converting to an economy based on the burning of fossil fuels. In the last two centuries there has been an exponential increase in the burning of these substances by the developed world and, more recently, a leap in the conversion by the developing world to massive carbon fuel use. The result is an impending world catastrophe from the CO_2 in the atmosphere. Democracies are not good at recognizing and addressing future hazards. Issues that are causing pain or profit *now* are the ones that draw attention. Climate warming gases, enough to cause disastrous consequences for human civilization, are already in the atmosphere. A significant portion of these climate-changing gases comes from the liquid fossil fuel—oil. Even if the peril to human civilization from a rapidly changing climate were not already upon us, the political, financial and security hazards of depending on this unreliable substance would be alarming.

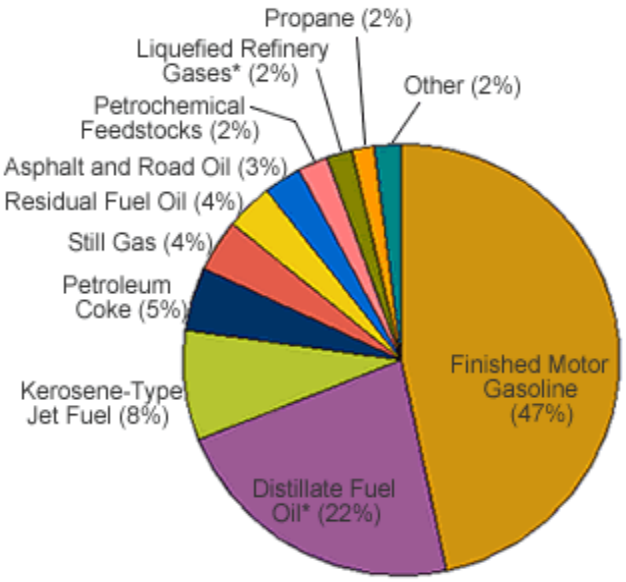
A Very Short History of the Oil Era

Petroleum is a naturally occurring substance that in ancient times was used for paving streets and sealing mummies. It became widely used in the 1800s for lighting in kerosene lamps and, after World War I, as fuel for internal combustion engines.[1]

Beginning in the 1920s the United States was a major oil supplier with large oil fields in Pennsylvania, Texas, Oklahoma, California and Alaska, but the US-based supply peaked in 1970 and has been declining since. Most of our remaining oil production comes from the Gulf of Mexico off Louisiana and Texas. Our present reserves, including those in environmentally protected offshore and arctic areas, can be expected to contribute only a negligible amount of our demand.

To put some numbers on United States oil use, we consume almost 20 million barrels a day (mbd) of crude oil and petroleum products, but produce only about 7 mbd, importing the remaining 13 mbd, about 65% of our oil consumption. Increasing demand in developing countries is contributing to the cost of the oil we import. The imbalance between our oil consumption and production is a national security issue, because, with only 3 percent of world reserves, the United States uses nearly a quarter of world production.

Current US Usages of Oil



Transportation

Fuel in liquid form is easily transported. Therefore, crude oil, a natural liquid, became the source of nearly all of the products that power the world's transportation system. As

shown in the above piechart from the United States Energy Information Administration, about 70% of the oil we consume in the United States is for transportation of people and goods by autos, trucks, aircraft and ships. Looked at another way, 96 percent of the transportation in this country is powered by petroleum, with only 2 percent powered by natural gas and 2 percent by renewable energy products such as ethanol. [2]

After WWII, with plenty of cheap, efficient and transportable gasoline, the US shifted to an automobile-centered society with populations spreading out into suburbs. Out of necessity or for convenience, most people now use their cars to commute to work and for nearly all of their transportation needs.

Transportation of goods by truck, ship or air has increased exponentially in recent years. Foods that were once available only in season are shipped to markets all year long. Moreover, we now have a world market with both agricultural and manufactured products transported all over the globe. A single product often is composed of parts that are made or added at locations in different countries and continents.

The transportation category includes the oil used by farmers to transport their crops to market, and also fuel to power the huge machines that traverse big monoculture fields in planting, fertilizing, pest protecting and harvesting crops. Food production, as well as distribution, depends on oil.

Industrial Oil Consumption

About 24% of the oil we consume in the United States is for industrial use, including use as a raw material for many chemical products including pharmaceuticals, solvents, tires and plastics. In agriculture, oil is the raw material for some pesticides and herbicides. In most cases, oil used in this way is not a contributor to climate change. A case can be made that production of needed chemicals is the highest and best use for oil and that securing a continuous and affordable supply for that purpose should be a priority. Industries also use oil to generate heat and power in their production processes. Put another way, 44% of the energy consumed by US industry comes from oil.

Residential and Commercial Use

About 5% of the oil we consume is for residential and commercial use, principally heating, although some commercial facilities have plants that combine electricity generating and heating. About 18% of residential and commercial heating comes from oil. Most of the country uses natural gas to heat homes and buildings (75%), but the northeast depends heavily on heating oil, making it particularly vulnerable to fluctuating oil availability.

Electric Power Production

Only two percent of the oil we consume is for public electric power production.

Future Petroleum Production and Pricing

In 1956 an engineer named M. King Hubbert predicted that oil exploration would one day lead to diminishing returns, with a decline in finding new oil fields followed by a world-wide decline in production that would follow a bell curve.[3] Since that time, we have seen a leveling off and decline of US oil production, with peak production in 1970. Fifty-four of 65 other major oil-producing countries also have declining production.

Hubbert and other oil specialists predicted that the price of oil would fluctuate widely as supplies declined in response to market conditions.[4] Escalating demands of emerging economies, added to the continuing demands of industrialized countries, exerted unprecedented upward price pressure and oil reached a high of $147.27 a barrel on July 11, 2008. However, in response, domestic demand fell and the use of alternate means of transportation such as public transit increased. In late 2008, a credit debacle sent the global economy into what may well be a long and deep recession, further decreasing demand. The prices of oil and gasoline have fallen sharply, but so has consumer and business spending. It remains to be seen what the net long-term effect on oil demand will be, but the Department of Energy expects continued increases as the recession eases.[5]

The exact date that peak oil will arrive is dependent on many things, including the development of new technologies that may replace some of today's uses of petroleum. For that reason, we make no attempt to predict when world-wide peak oil production will occur, but instead look to the effects that declining oil production will have in addition to the changes that will be brought by an anticipated increased cost of oil. We note that the threat to the earth's ecosystem and human civilization from the burning of fossil fuels creating global climate change has not abated since our prior study in January 2008, nor has the threat of depending on unstable and even hostile countries for a depleting resource for which we currently have no substitute.

Alternatives to Oil and Adaptations to a New Economy

There are no liquid fuel substitutes in quality and quantity

to replace the one-time natural gift of petroleum. However, society is exploring alternatives. Fuels such as ethanol, methane, propane, biodiesel liquid coal, and hydrogen all have potential, as well as serious drawbacks.[6] Biofuels, ethanol and biodiesel, supply about 3% of our liquid fuels use now, but are projected to consume one-third of the U.S. corn crop for ethanol and soybeans for biodiesel by 2009.[7] This will drive up food prices world wide. Further growth of biofuels is limited by ecosystem constraints and competition with food needs. Propane is a natural gas liquid that is expected to peak along with natural gas about 10 years following the oil peak. Methane is a potent greenhouse gas with 23 times the global warming effect of carbon dioxide. Although methane has been considered a transition fuel, its use on a massive scale could speed the planet toward uncontrolled global warming. Liquid coal production also emits very large volumes of greenhouse gases. Hydrogen is an omnipresent element found in compounds with oxygen, carbon and other elements. However it is difficult to separate into its elemental form. Hydrogen cars for the mass market may be decades away because of the cost of producing pure hydrogen and the need of a new distribution infrastructure.

Natural gas is now used for electricity production, home heating, industrial processes, and to a lesser extent to power some fleet vehicles. Utah has made municipal fueling stations available to the public and natural gas cars are in high demand as a result.[8] Since it is a relatively clean burning hydrocarbon compared to oil and coal, natural gas is considered to be a transition fuel to renewable sources, provided the distribution infrastructure can be modified to accommodate private transportation fueling stations.

Due to the problems developing these alternative fuels on a large commercial basis, the most likely initial alternative fuel will be conservation. For example, in the summer of 2008 many people changed their commuting habits and their vacation plans in response to the increased cost of gasoline, lowering demand enough for gas prices to decline in August. Automobiles and trucks that are more fuel efficient, including gas/electric hybrids and new generation diesels, were becoming more common. Carpooling and the use of mass transit boomed. Localities planned to increase funding for all forms of mass transit, including bus lines and passenger rail systems such as the METRO and VRE. Increased use of motorcycles and bicycles led to the need for more bike lanes and secure parking, as well as driver education to reduce automobile/bike accidents. Finally, travel by airplane became much more expensive as fuel is the major cost component of air travel.

Now with the nation in recession and oil prices less than half of their 2008 highs, we will see whether the long-term transportation conservation measures begun during the price rise continue. Though jet fuel prices have fallen, so far, airfares have not. The drop in consumer incomes and credit access will probably depress air travel. Shorter trips can sometimes be accomplished by passenger rail or long-distance bus lines, but with the low-cost airfares that were available over the past twenty-five years, those mass transit options have deteriorated so much that they do not have the capacity to absorb additional passengers in the near future. Rail is far and away the most fuel efficient way to move people or freight. It must be restored in the U.S.

Personal Transportation Adaptations

Hybrid gas-electric cars are available today and plug-in hybrids will soon be available if automobile manufacturers retool their production facilities. They cost more to purchase, but with higher gasoline prices become cost-effective choices over the life of the car, some models within one year even without the federal incentives. Some new small internal combustion cars rival hybrids for fuel efficiency. Diesel engines had a reputation as being heavily polluting. Clean Diesel, now available for sale in the United States, is erasing that reputation. Biodiesel is partially refined plant oil, including used cooking oil that can be burned in a regular diesel engine. Most biodiesel is currently produced from soybeans, a food crop. Certain strains of genetically engineered algae grown in greenhouses may be economically viable as fat sources for biodiesel.[9] An added benefit of using algae to produce the raw material for biodiesel is that it can be grown at an industrial site with a secondary benefit of recycling CO_2 from industrial smokestacks. Like regular diesel, a biodiesel car or truck may have problems starting in cold weather, but the engine requires much less maintenance than a gasoline engine and its higher mileage compensates in part for the current higher cost of diesel fuel.

All-electric vehicles (EV) are now available commercially, but models comparable to a standard passenger car cost more to purchase and their expensive batteries must be replaced periodically. Car companies and research institutions are working assiduously to create new and better batteries. With expected improvements in battery charge time, EVs show great promise as a cheaper-to-operate replacement for passenger cars and local delivery trucks, which return to their garage every night. Electricity to recharge these vehicles can be made with renewable resources like wind or solar power.

Passenger transportation needs can be addressed through

changed work conditions, too. Telecommuting is a "…work arrangement in which employees enjoy flexibility in working location and hours. Workers replace the daily commute to a central workplace with telecommunication links which allow them to work from mini-office stations sited in residential suburban areas or from home or even from coffee shops or other places equipped with wifi technology. Telework is a broader term which refers to substituting telecommunications for any form of work-related travel thereby eliminating travel." [10] Another way of describing teleworking is to say that it "…is a way of working in which the work is carried out at a distance from the employer or constructor for whom it is intended." Due to its emphasis on sustainability, the percentage of high-tech companies, and advanced telecommunications infrastructure, metropolitan Denver is one of the top areas for telework. The Census Bureau reporting on commuting patterns noted that more people work at home in Colorado than in any other area of the nation overall.

Freight Transportation Adaptations

Passenger transportation is frequently our first thought, but the cost of moving all consumer products is also dependent on liquid fuels. Most freight in the United States is moved by truck (59%), followed by pipeline (19%), railroads (9.73%), intermodal (7.17%), water (3.28%) and air (0.07%). There is no easy alternative for local truck deliveries, but long distance freight can be hauled four times more efficiently by trains as seen by the large number of piggy-back truck trailers and shipping containers carried by freight trains. Trains also haul heavy bulk materials such as coal, aggregates and bulk grains. Trucks haul finished products that do not weigh as much, and trucks can go to locations that are not served by rail. To take advantage of their energy efficiency, freight rail lines must expand capacity before they can handle an increase in demand, including strengthening rails and beds and building more off-loading facilities to switch rail to trucks for local delivery. We will continue to need both freight transportation modes into the foreseeable future.

Building Adaptations: Residential and Nonresidential

As noted above, most of the country uses natural gas for heating, however, much of the northeast, which has especially cold winters, is dependent on fuel oil for heat. Conservation measures such as increasing insulation, installing multi-pane windows and improving weather stripping can reduce fuel oil needs significantly. Retrofitting buildings for energy savings and renewable energy will be a growth business. A move towards heat pumps, especially geothermal ones, could reduce fuel oil dependence in the Northeast. Many new buildings are also being designed to use less energy, under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System.

Community-Wide Adaptations

As oil reserves are depleted, making our lives less mobile and the goods we buy more expensive, our lifestyles will necessarily change. Workers will locate closer to their jobs and to mass transit. The more compact communities may produce some of their own food, goods and perhaps even electricity. Imported goods will increase in price, boosting local production and repair. The market may help to create local businesses within walking or biking distances to decrease motor vehicle usage and save money. Americans may even feel a need to reduce consumption and waste. Several communities have already begun to make these changes. For example, Fairfax County's Comprehensive Plan designates eco-friendly land use areas, which place relatively dense housing, employment centers, mass transit and pedestrian friendly retail in a compact mixed-use community. Reston, Fair Lakes and the plan for Tyson's Corner are examples of these new edge cities. Community gardens are already popular features in a number of county parks, as are home vegetable gardens and farmers' markets that provide access to locally-grown food.

Portland, Oregon, has created a Peak Oil Plan that anticipates that the city will have half of the oil it now uses in 25 years with the average citizen receiving only one third as much. To get people out of their cars, the city has built two new commuter rail lines and the Portland Streetcar. It, too, will attempt to limit sprawl by encouraging mixed-use development.[11]

Futurists are predicting that lifestyles will change drastically from being isolated and consumer-based to being more closely bound communities with increased sharing, cooperation and local self-sustainability. Such communities are emerging and may be demonstrated by two models–permaculture and transitional models. Elements of each of these models may be found in Europe, Asia, and the Americas.

Permaculture, as defined by Grahm Bell, is the conscious design and maintenance of agriculturally productive systems which have the diversity, stability, and resilience of natural ecosystems.[12] In other words, permaculture is the result of humans designing gardens, orchards, landscapes, and homesteads that mimic the processes of a natural ecosystem. Permaculture was devised in the 1970's by professors Bill Mollison and David Holmgren in Australia. Permaculture has evolved from a design system for permanent agriculture to conserve soil nutrients and water into an integrated design

concept for communities.

The Transition Town movement was originated by Rob Hopkins in England in 2005 to prepare foundations of the transition concept.[13] The transitional approach is distinct from other environmental approaches to living. The transitional approach involves working purposefully with members of a community to find practical ways to withstand external shocks. The community seeks to become more resilient by becoming more self-reliant in areas such as food, energy, health care, jobs and economics.

Future Energy Technology

The life-style changes enumerated above would reduce our oil use. But they will not be sufficient or come fast enough to save the day. The essential remedy for the threats of oil depletion, of climate change, and other environmental crises is the creation of new and revolutionary energy technologies. With government backing, we need an all-out innovation effort by research centers, venture capital, industry and startup inventors to create a new energy system that can replace the fossil fuel one we now employ. Electricity will surely be the universal engine because it can be produced from better sources and used more cleanly and safely than present options. We will need a new generation of batteries to power future vehicles, new systems to retrofit existing vehicles to reduce or eliminate their use of gasoline, a bigger and much improved electric grid to bring power generated by sun, wind and other alternate sources to markets. Time is short, but new electronic capabilities have been coming to market with amazing speed. For example, consider the change from incandescent light bulbs to energy efficient compact fluorescents to even more energy efficient LEDs. We must believe that these far more important changes can be made, and do all we can to see that they are.

Bottom Line

The credit collapse and the global recession we now face will affect the demand for oil and its price for as long as consumption and industrial production are constrained. However, the limits of world supply are unlikely to change.

In his report, "Peaking of World Oil Production: Impacts, Mitigation and Risk Management" for the Department of Energy in 2005, Robert L. Hirsch stated, "The world has never confronted a problem like this, and the failure to act on a timely basis could have debilitating impacts on the world economy. Risk minimization requires the implementation of mitigating measures well prior to peaking. Since it is uncertain when peaking will occur, the challenge is indeed significant."[14] Dr. Hirsch indicated that 20 years and trillions of dollars would be required to avoid economic instability.

If the U.S. has not prepared for this event, and an "oil crunch" does occur, as forecast by the International Energy Agency and the National Petroleum Council, in the 2012-2025 time period, we can expect severe times ahead in transitioning to a postcarbon world.

Endnotes

1 United States Energy Information Administration. We consulted the website of this Department of Energy office for much of the background information discussed in this article, including the history of petroleum production and descriptions of production and consumption of various other types of energy. www.eia.doe.gov.

2 U.S. Primary Energy Consumption by Source and Sector, 2007, accessed at http://www.eia.doe.gov/emeu/aer/pecss_diagram.html.

3 Deffeyes, Kenneth S., *Beyond Oil, The View From Hubbard's Peak.* Hill & Wang, New York. 2005.

4 Ibid.

5 Annual Energy Outlook, 2009, early release summary, accessed at http://www.eia.doe.gov/oiaf/aeo/index.html.

6 The Department of Energy publishes information on alternate fuels, as well as an annual report on greenhouse gases that result from combustion of all fuels.

7 Westcott, Paul, *United States Ethanol Expansion Driving Changes Throughout the Agricultural Sector.* U.S.D.A. Amber Waves. Sept. 2007, accessed at http://www.ers.usda.gov/AmberWaves/September07/Features/Ethanol.htm.

8 Krauss, Clifford, *Surge in Natural Gas Has Utah Driving Cheaply*, NY Times, September 2, 2008.

9 Biodiesel production from algae: www.cnn.com/2008/TECH/science/04/01/algae.oil/index.html; www.greenfuelonline.com/news/algaefuel.pdf; http://www.unh.edu/p2/biodiesel/article_alge.html.

10 Telework/telecommuting: www.metrodenver.org/working-here/telework.

11 Portland Peak Oil Plan, accessed at www.portlandonline.com/osd/index.cfm?c=42894

12 Hopkins, Rob, *The Transition Handbook*, Green Books Ltd. Foxhole, Dartington, Totnes, Devon 2008.

13 Ibid.

14 Hirsch, Robert, Roger Bezdek, Robert Wendling, *Peaking of World Oil Production: Impacts, Mitigation and Risk Managemen*t, United States Department of Energy, 2005. Accessed at : http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf.