2006

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P.T. Vasudevan
University of New Hampshire

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P.T. Vasudevan

Chemical Engineering

College of Engineering and Physical Sciences

Crude oil or petroleum and natural gas have an important role in our everyday life. During refining, the complex organic molecules found in crude oil are broken down into much smaller species. These building blocks are recombined to form many useful products, including gasoline, plastics, life-saving drugs, synthetic fiber and rubber, and many others. In the United States, oil is the fuel of transportation. Coal, nuclear, hydropower, and natural gas are primarily used for electric power generation. With five percent of the world's population, the U.S. consumes 25 percent of the world's petroleum, 43 percent of the gasoline and 25 percent of the natural gas.

Oil and natural gas are fossil fuels formed from the remains of prehistoric animals and plants. The process took place hundreds of millions of years ago when these remains, mostly organic matter, under high pressure and temperature, converted to petroleum in the pore spaces of rocks. Oil and gas are non-renewable sources of energy.

According to *Oil and Gas Journal (O&GJ)* estimates, worldwide reserves at the beginning of 2004 were 1.27 trillion barrels of oil (one barrel is 42 gallons) and 6,100 trillion cubic feet of natural gas. These are proven recoverable reserves. At today's consumption level of about 85 million barrels per day of oil and 260 billion cubic feet per day of natural gas, the reserves represent 40 years of oil and 64 years of natural gas.

The U.S. Geological Survey carried out a study engaging 40 eminent geologists between 1995 and 2000 suggesting that in 2025, the world would have at least 900 billion barrels of undiscovered oil. Factoring this into calculations with reserve growth (i.e., the increase in recovery rate based on improved technology), and with consumption growth expected to reach 119 million barrels of oil per day by 2025, we see that oil availability may extend to 2091. This is based on reserves totaling 2.9 trillion barrels, about a one-fiftieth part of the water in the Great Lakes. For natural gas, a rise in consumption to 415 billion cubic feet per day by 2025 has only been indicated.

Peak production of oil from a reservoir typically occurs 10 years after discovery. For reasons of reservoir efficiency, oil is produced in increasing steps, year to year until the peak is reached, and then in decreasing quantities, year to year. M. King Hubbert, a distinguished geologist at Shell, predicted in 1956 that the U.S. oil production in all its reservoirs on land would peak in the early 1970s and in the world in 2000. While oil production in the contiguous 48 states did, in fact, peak in the early 1970s, global oil production has not reached a maximum.

In his latest bestseller, *Beyond Oil: The View from Hubbert's Peak*, K. Deffeyes of Princeton University argues that, "world oil production is going to decline first slowly, and then more rapidly." While some scientists, the "Hubbertons" believe that world oil production has already about peaked, the U.S. Geological Survey estimates that this is likely to occur around 2037. What is clear in this debate is that oil will run out one day, but not so soon.

The oil and gas industry is a high technology industry. Technology innovations have made it easier to find new deposits of oil and gas and enhance recovery. Improved techniques, such as 3D and 4D seismic technology, combined with the power of computers, have raised the probability of finding more oil and gas. Others, such as directional drilling to reach target areas even five miles distant, have enhanced oil recovery as well as environmental protection. Offshore, wells are routinely drilled in 5,000 feet of water, and well depths go thousands of feet below the ocean floor. Global Positioning System technology has helped to spot precisely locations for offshore activities.

A few decades ago, the average oil recovery rate from reservoirs was 20 percent. Today it stands at 35 percent. New techniques would increase the recovery rates. Peaking would occur later than now envisaged and optimism seems justified. Assume that the U.S. Geological Survey and the "petro-optimists" are correct, and that the future for oil availability is indeed bright. Assume that Morris Adelman of MIT is also correct when he declares that the "amount of oil available to the market over the next 25 or 50 years is for all intents and purposes infinite." Should we remain complacent, or is this the right time to look for alternative fuels?

Do other reasons warrant action? The price of oil and gas, geopolitics and security of supply, and global warming concerns are highly relevant. Oil and gas occur in a few countries, and oil-exporting countries are either in a cartel (OPEC) or band loosely together. Until a few years ago, world demand was running a little below capacity to supply. The producing countries allocated production quotas among them. Saudi Arabia, the largest producer, retained some flexibility in accepting an allocation below capacity to produce. When demand went into a spurt on occasions, the Saudis would produce some more.

A well- matched supply and demand led to stability in the price of oil. But in recent years, demand has perked up. Consumption by the U.S. has gone up, Iraq's production is hampered, and developing countries such as China and India have been importing more and more oil. Saudi Arabia has lost its swing production ability, itself producing to full capacity. This mismatch between demand and supply, although marginal, has apparently resulted in the ongoing sharp jump in oil prices.

On the supply side, the issue is how soon the producing countries can tap undeveloped reserves. Huge investments of time and money are required. On the demand side, however, quicker progress is possible. Obviously, in our own interest, we should reduce our consumption through conservation, higher energy efficiency, and a turn to alternative resources.

Many economists rightly believe that an oil price shock will help us consume less of the resource. Consider the May 2006 prices of various fuels based on heating value. Per million BTUs, the cost of seasoned firewood in the northeast U.S.is about $10, natural gas $15, No. 2 fuel oil $18, and gasoline $24 (a trip to Boston and back in an SUV). Who wouldn't wish to economize on the use of petroleum?

With oil at high prices, alternate renewable energy becomes attractive. Many of these are eco-friendly. Take ethanol as an example. Sugarcane-based ethanol edges out gasoline at an oil equivalent economic price of $40 per barrel. In contrast, U.S. corn-based ethanol has an edge over gasoline when oil price is $60 or higher. Gasoline in Brazil has a 25 percent ethanol component. That country will become self-sufficient in energy this year.

"Flex-fuel" vehicles are designed to run on ethanol, gasoline, or a mixture of the two. Ethanol is made through the fermentation of sugars, and sugar cane offers many advantages. Sugar cane based ethanol is said to yield eight times as much energy as corn. Unlike corn-based fuels, sugarcane requires no fossil fuels to process. Cellulosic ethanol, derived from a range of crops, such as switch grass and crop waste, is more economic than corn ethanol because it requires far less energy. Ethanol reduces carbon monoxide and other toxic pollution from the tailpipes. And because ethanol is made from crops that absorb carbon dioxide, it helps reduce greenhouse emissions. It should be noted that ethanol, necessarily in mix with gasoline, would only partially replace gasoline.

Besides ethanol, other unconventional choices are: biodiesel made from agricultural crops or waste cooking oil that is blended with diesel; gas-to-liquids (GTL) from the abundance of natural gas, coal, or biomass; oil trapped in the shale formations in the West, and heavy oil lodged in the Canadian tar sands.

Biodiesel blend is already in progress. Gas-to-liquids, too, has been in operation for many years, and the prices are right for these to expand in a big way. The use of compressed natural gas (CNG) in motor vehicles is common in many developing countries—but not in U.S. There are the conventional energy resources, such as hydropower, nuclear power, and coal. But these do not readily substitute oil in transport, the prime need in U.S today.

Hydrogen powering of cars may not be viable unless hydrogen can be generated from other than fossil fuels. The emerging combination of hydrogen and fuel-cell technology may get a boost with nuclear power. Nuclear power has a good safety record, but the problem of radioactive waste disposal needs to be solved.

Geopolitics and national security furnish important reasons for the U.Ss to become less dependent on imported oil. A scenario of events that includes unrest in Nigeria, a terrorist attack on Saudi Arabia's Ghawar field or processing facility in Haradh, would seriously interrupt supply. The present spike in oil prices offers a wakeup call for us to adopt all measures towards self-sufficiency. We must boost research on alternative fuels and use these fuels, lower consumption, and raise efficiency through higher fuel-economy standards. We have the potential to take the giant steps needed to make us less dependent on imported oil, but we must act now.

Books you can read

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Howe, J.G., *The End of Fossil Energy*, McIntire Publishing, 2005

Huber, P.W., and Mills, M.P., *The Bottomless Well*, Basic Books, 2005

Klare, M.T., *Blood and Oil*, Owl Books, 2004

Simmons, M., *Twilight in the Desert*, Wiley and Sons, 2005

Web Sites

Energy Information Administration, www.eia.doe.gov

Society for Petroleum Engineers, www.spe.org

Global Oil Crisis, http://oilcrisis.com

Petroleum issues, http://petropeak.com

Courses you can take at UNH

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