PEAK OIL – AN OVERVIEW

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Much has been written about the concept of "peak oil" in recent years. Peak oil does not mean that no more oil exists. It means is humans have used about half the Earth's endowment of oil. Once the peak is reached, global oil production can no longer be maintained or increased. Annual oil production will level out and begin a long-term decline. Production will no longer be able to meet growing demand as it has in the past.

Peak oil typically encompasses the idea of peak natural gas as well. Natural gas follows a production curve similar to oil. World natural gas is expected to peak perhaps a decade or two later than oil. However, the U.S. is expected to experience the effects of declining natural gas production sooner than that. North American gas production appears to have peaked in the past few years. It is more expensive to import natural gas than oil. It has to be liquefied for transport and storage and then re-gasified for distribution.

Oil accounts for about 40 percent of the energy we use, and natural gas accounts for another 25 percent. Oil provides virtually all our transportation energy, and natural gas heats nearly half our building space and generates 7-15 percent of Oregon's electricity. In addition, oil and natural gas are used for numerous industrial processes, including use as a feedstock for thousands of products such as asphalt, fertilizers, pesticides, plastics, chemicals, paints, medical products, vinyl, and shoes and apparel.

Peak oil could have a major impact on the U.S. and world economies. All the major recessions of the past 35 years were preceded by sharp increases in the price of oil. The energy crises of the 1970s provide a preview of the impact of peak oil. U.S. oil production peaked in 1970 and started a decline, which continues to this day. We turned to imports to make up the shortfall. The Organization of the Petroleum Exporting Countries (OPEC) used this growing dependency for political purposes, cutting production 6-7% in 1973 and tripling prices. As a result:

- Gross National Product growth fell from 4% in 1960-73 to 1.8% in 1973-82;
- productivity growth dropped from 2.5% in 1966 to less than 1% in 1979;
- unemployment rose from 4.8% in 1972 to 8.3% by 1975;
- inflation was 8.8% for the decade; and
- take home pay dropped 6% from 1973 to 1979.

High prices stimulated energy conservation and development of more expensive, harder-to-get supplies from places like Alaska and the North Sea, and eventually OPEC was forced to reduce prices. However, this time there's no major new resource areas to develop. The impacts could be deeper and last longer than they did after U.S. oil production peaked.

Opinions differ as to when production will peak. Some experts believe the peak is imminent or has already happened. Many believe it will occur in the next 10 to 15 years. The most optimistic opinions place the peak around 2030 to 2040. The primary difference revolves around estimates of earth's ultimately recoverable reserves and the effect of prices in stimulating advanced recovery and development of unconventional resources. Generally speaking, the lower estimates tend to come from petroleum geologists and physicists, the higher estimates from economists.

A review of the data leads us to conclude the peak likely will occur sooner rather than later. Among our observations are the following:

1) Trends of both discoveries and production point to a global resource base of about 2.2 trillion barrels of oil. The world has already used more than one trillion barrels, and is currently using more than 30 million barrels per year.

2) Optimistic estimates that the earth holds 3 trillion barrels of recoverable oil would require a reversal of historic discovery trends and a doubling of estimates of remaining reserves.

3) In the long run, production cannot exceed discoveries. Experience in many oil-producing nations indicates that production lags discovery by 25 to 40 years. For example, in the U.S., discoveries peaked in the early 1930s, and production peaked in 1971. World discoveries of oil peaked in the mid-1960s, and have declined ever since.

4) Discoveries fell below production in the mid-1980s and have continued to fall. The world currently finds one barrel for every four or more that it uses.

5) Higher oil prices and increased drilling have not resulted in increased discoveries. New discoveries have tended to be fewer, smaller, deeper, more remote, and more costly. The largest, most easy-to-find deposits are likely to already have been found. For example, a much-heralded discovery in the Gulf of Mexico recently is located in a hurricane-prone area under 7,000 feet of water and another 20,000 feet below the ground, and contains 1 to 6 months worth of oil at current rates of consumption – the costs of producing this would be high, and it would not noticeably delay the peak.

6) About two-thirds of oil-producing nations have already peaked and are in decline, including the U.S., Mexico, and the North Sea (U.K. and Norway). At least two of the world's five largest fields ever found – Burgan in Kuwait and Cantarell in Mexico – have peaked and begun to decline, and there is concern that Saudi Arabia is having difficulties maintaining production from the world's largest field, Ghawar.

7) Knowledge of where oil may or may not be located is more extensive than ever. Geologists have identified what kind of geological formations are likely to produce and hold oil, and the earth's geology has been extensively mapped. In addition, millions of wells have been drilled looking for oil and other resources. The likelihood of finding new fields comparable to those in Middle East, Texas, Russia, Mexico, or the North Sea, is very low.

8) Estimates of existing reserves are unreliable. Reserve estimates of OPEC member nations jumped 60 percent in the late 1980s. This was likely due to a link between proved reserves and production quotas. In the past two years, Shell Oil and Kuwait downgraded their estimates of proved reserves by 20 and 50 percent, respectively.

Several other forces could create conditions that would also require reductions in U.S. oil consumption, like peak oil.

- Geopolitical events may affect production of fossil fuels. Most of the remaining oil and natural gas is in nations that are either unstable or hostile to the U.S., and several scenarios could limit productive capacity or output.
- The production and use of fossil fuels may have to decline rapidly to reduce carbon emissions in response to global warming concerns.
- A decline in the value of the dollar relative to other currencies could reduce our purchasing power and force the U.S. to reduce its share of oil use to levels commensurate with its share of the world population. The U.S. currently has about 5 percent of the world's population, but uses about 25 percent of the world's oil production.

Many believe higher prices will stimulate either new discoveries or the development of alternatives. For example, Cambridge Energy Research Associates, a major economic consulting firm, released a report in November 2006 claiming that world oil production will not peak before 2030. This is based on the highest estimate of developable resources to date, and has come under criticism from many. In particular, CERA projects that the market will stimulate more production from advanced recovery techniques, Canadian oil sands, and oil shale than others forecast. The Oregon Department of Energy's review of the literature suggests these resources will cost more and be developed more slowly than CERA assumes.

Below is an assessment of some of the major supply alternatives. While alternatives will be used in some measure, they are unlikely to fully replace oil and natural gas. All have a lower energy return on energy invested (EROEI) than oil or natural gas – that is, they take more energy to produce and yield a smaller net energy gain. For example, most of the alternatives yield 2 to 5 units of energy for every unit needed to produce them. This compares to oil and gas which historically have had net energy ratios of 20:1 and greater. As a result, the alternatives are less productive and more expensive.

In addition, the alternatives produce electricity rather than liquid transportation fuels, have significant environmental problems, or will have their own supply constraints, particularly if production is increased to offset declining oil and gas resources. All would take decades to replace a significant amount of declining oil and natural gas reserves.

1) *Coal* is abundant in the U.S., with 240 years worth of reserves at current use rates. It can be used to generate electricity or can be made into gaseous or liquid fuels. However, increased use of coal would seriously aggravate global warming. Much of the CO_2 could be sequestered, but it would require about one-fourth of the energy in the coal to do so. In addition, coal use would have to quadruple or more to displace oil and natural gas. But if U.S. coal use increased just 2 percent per year, the lifetime of our coal reserves would drop to 85 years and lead to a "peak coal" problem in the not-too-distant future.

2) *Nuclear power* produces only electricity, which means it is not well suited to replace oil as a transportation fuel. Even if nuclear power could meet all U.S. energy needs, the 10-fold increase in nuclear power plant capacity would require massive infrastructure costs. With that many plants in operation, known reserves of uranium would be depleted in about 20 years. Breeder reactors could extend the life of uranium reserves, but safe, affordable breeder reactors are not currently available. Nuclear power also poses the problems of nuclear waste disposal and nuclear weapons proliferation. Oregon has had strong opposition

to nuclear power, and Oregon's only nuclear plant was closed early because of leaking steam tubes.

3) *Oil sands* in Canada and Venezuela are abundant. However, the oil is not in liquid form, but rather more like sand-impregnated asphalt. This makes oil sands extraction land- and water-intensive, polluting, and high in carbon emissions. In addition, it has an EROEI of about 3-to-1, meaning it takes about one-third of the energy in the oil sands to produce it.

4) *Oil shale* has many of the same environmental problems as oil sands. In addition, oil has never been produced commercially from shale. Shale oil has an estimated EROEI of about 1.5-to-1, meaning two-thirds of the energy it yields must be used to produce it. This would increase the amount of CO_2 emitted. Capturing the CO_2 would further reduce net energy.

5) *Enhanced oil recovery* involves advanced methods to extract more oil from a field, such as in-fill drilling, horizontal drilling, hydraulic fracturing, and injection of solvents like CO_2, nitrogen or steam to make the oil move more easily. Because of costs, enhanced recovery is unlikely to affect an oil field's peak since it is not typically applied until after production has peaked. Recent studies also suggest these methods simply allow the oil to be extracted a little faster, with the total amount of oil produced from a field remaining about the same.

6) *Biofuels (biodiesel and ethanol)* are highly touted to replace oil for transportation. Biofuels are carbon neutral, meaning the CO_2 they emit is balanced by the CO_2 they need to grow. However, biofuels would compete with other uses of the land, such as food, forest, erosion control, and habitat. In addition, most ethanol in the U.S. is now made from corn, which is oil- and natural gas-intensive to grow and, as a result, has a low energy return – best-case analysis estimates the EROEI at about 1.67-to-1. There are hopes that ethanol will be able to be made from cellulosic plants such as switchgrass, which are less energy intensive and can be grown on marginal lands. However, this is still in the research stage. Biodiesel has a better EROEI (3-to-1 or slightly greater) than ethanol, but will probably require dedicated crops and cropland, thereby limiting the amount that can be produced. While biofuels hold some promise, they are unlikely to replace more than a small share of the petroleum-based liquid fuels currently used.

7) *Hydrogen* is often touted by many as the clean, renewable fuel of the future. However, hydrogen is an energy carrier, not an energy source. It is not found in its most useful state–H_2–but must be separated from other atoms to which it is attached, such as carbon or oxygen. Most hydrogen today is produced from natural gas. This is not sustainable when natural gas is in decline. In the long run, if hydrogen is to be used as a transportation fuel, it will have to be electrolyzed from water using renewable power. But because of thermodynamic losses in producing and transporting the hydrogen, it may be more efficient to use the renewable power directly. In addition, because of its volume and because it leaks so easily, hydrogen is difficult to store and distribute. The current storage and distribution infrastructures for natural gas and gasoline would have to be replaced, at huge costs, to accommodate hydrogen.

8) *Clathrates* are ice crystals containing methane (i.e., natural gas) found at the bottom of oceans. The potential resource is immense. However, methane is a more potent greenhouse gas than CO_2, and release of even part of this methane could trigger runaway global warming. At this time it is not technically feasible to capture the methane for commercial use without a large portion escaping.

9) *Renewables (wind, solar, biomass, wave power)* will need to be developed to the fullest extent possible, and fortunately Oregon is well-endowed with them. However, aside from biofuels, most renewables produce electricity or thermal power (heat). Their applications rarely include transportation. While abundant, it is not clear how much of our total energy needs renewables will be able to meet. The immediate need for renewables is to meet electric load growth, then to begin displacing coal and natural gas in electrical generation to reduce CO_2 emissions. In addition, fossil fuels are required to build renewable power plants. We need to begin building the infrastructure now while cheap oil and natural gas are still available. They will be more expensive and difficult to build once oil and natural gas supplies are declining.

In addition to alternative supplies, it will be necessary to reduce how much energy we use. While we cannot conserve our way to zero, we will need to use less energy in the future than we use today. With the peak of world oil production approaching, we need major improvements in energy efficiency – we need to improve the efficiency of our cars, our homes and buildings, our lights and appliances, our industrial processes. In addition to technology improvements, we will need to restructure various institutions and systems. For example, we should reinvigorate our rail system, develop mass transit, and change land use patterns to reduce the need to travel. We will also need to change behaviors. We should ride share, walk and bicycle more often, and vacation closer to home.

Regardless when the peak occurs, the implications are potentially profound. It would be prudent to begin to act now. Robert Hirsch, co-author of a highly regarded report completed for the U.S. government entitled "Peaking of World Oil Production: Impacts, Mitigation, and Risk Management," concludes that peak oil is going to happen, although the timing is uncertain, and that it could cost the U.S. economy dearly. The report further concludes that to have substantial impact, mitigation options must be initiated more than a decade in advance of peaking and will cost in the range of $1 trillion. The costs of acting too late will exceed the costs of acting too early.

The solution will require a massive effort. It took decades to develop coal, oil, and natural gas into significant energy sources. It will take decades to transition to a new way of doing things, and will require large amounts of capital and energy. If we wait until the peak occurs, we will be trying to build the new infrastructure at the same time that energy supplies are declining, prices are rising, and we're struggling to maintain other services. Energy efficiency and renewable energy technologies will provide a strong base for jobs and profits in the post-peak oil-and-gas economy, and can serve as an economic development tool for Oregon. We must begin now.