PEAK OIL – AN OVERVIEW

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Much has been written about the concept of "peak oil" in recent years. This introduction will summarize the key conclusions and uncertainties that will inform the Task Force in its work. For details or a more in-depth discussion of the issues, many books and web resources are available.

What is "Peak Oil?"

The term "peak oil" refers to the idea that the rate of global oil production is near or past its peak and will soon begin a long-term decline. When an oil field is developed, there is a maximum rate of production which can be sustained without damaging the field – if it is pumped too fast, groundwater may intrude or the internal structure of the field may otherwise be compromised. That eventually happens anyway when about half the oil in a field has been produced, and it becomes more difficult and expensive to pump what remains. At that point the production rate can no longer be maintained, and it begins to decline.

Regional or national production is maintained or increased by adding production from new fields, not by pumping more out of existing fields. When production from a large number of fields has peaked and begun to decline, and there are not enough large new fields being found and developed to offset the lost production, the system is said to have peaked. As with individual fields, this is expected to happen when about half or slightly more of the ultimately recoverable oil has been produced. Peak oil does not mean that no more oil exists, but that we're at the point where global production can no longer be maintained or increased. Production will no longer be able to meet growing demand as it has been able to do in the past. Instead, production will begin to decline, year after year, and demand must decline at the same rate as production. Prices will rise, and we will either have to find alternatives or experience economic and social consequences, or both.

Peak oil typically encompasses the idea of peak natural gas as well. Natural gas is often found in association with oil (it is also found "non-associated"). It has many similar uses, and oil and gas can often be substituted for one another. Together oil and natural gas account for 65 percent of the primary energy used in the U.S. and worldwide. 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 sooner than that. North American gas production appears to have peaked in the past few years and, unlike oil, it is more difficult and expensive to import replacement natural gas from overseas – it has to be liquefied for transport and then re-gasified for distribution.

How Sure Are We About Peak Oil?

Oil is a finite, non-renewable resource. As a limited resource, it is inevitable that the ability to extract it will eventually peak and begin to decline. The only question is when. Is that day a long way off, or is it close? Is there cause to be worried?

Opinions differ as to when production will peak. Some experts believe the peak is imminent or has already happened. Others 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 two related questions: estimates of how much oil remains to be discovered, and estimates of earth's ultimately recoverable reserves.

A review of the literature leads us to conclude the peak likely will occur sooner rather than later. There is no single conclusive piece of evidence; rather, there is a preponderance of evidence pointing toward this conclusion. The reasons are outlined below.

1) In the long run, production cannot exceed discoveries. Experience 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.
2) World discoveries of oil peaked in the early 1960s, and have declined ever since.
3) Discoveries fell below production for the first time in the mid-1980s and have continued to fall. That means the world is currently drawing down reserves. The world currently finds one barrel for every four-to-six it produces and uses.
4) The modeling technique developed by petroleum geologist M. King Hubbert in 1956, which predicted the peak of U.S. oil production in 1970, has been updated and shows world oil peaking in this decade. Hubbert himself predicted world oil would peak at the beginning of this decade.
5) New discoveries have tended to be fewer, smaller, deeper, more remote, and more costly. Large, easy-to-find deposits are likely to have been discovered first.
6) 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 Saudi Arabia, or even the U.S., Iran, Mexico, Kuwait, or the North Sea, is very low.
7) Additions to reserves have typically come from updating the estimates of old discoveries, not from new finds.
8) Estimates of existing reserves are unreliable. Reserve estimates of OPEC member nations were increased about 60 percent in the late 1980s for political reasons relating to production quotas. In the past two years, Shell Oil and Kuwait downgraded their estimates of proved reserves by 20 and 50 percent, respectively.
9) The reserves-to-production ratio (i.e., how many years worth of oil remain at current production levels) has been declining.
10) 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).
11) 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.

12) Estimates of ultimately recoverable reserves have held reasonably steady at about 2 trillion barrels or slightly more for fifty years. The world has used about 1 trillion barrels to date. Optimistic estimates that the earth holds 2½-to-3 trillion barrels of recoverable oil would require a reversal of discovery trends and a doubling of remaining reserves.

Arguments Against Peak Oil

The main arguments against peak oil, with a brief response, are as follows.

1) Reserves have been growing. However, as indicated above, evidence suggests current reserves may be over-estimated.

2) Current problems are political in nature. It is true that political problems in Iraq, Iran, Venezuela, and Nigeria may affect current prices and production, but they do not address long-term trends in discoveries. In addition, to the extent current prices are influenced by geopolitics, we must ask how much those geopolitical forces are also being influenced by concerns and struggles over long-term oil supplies.

3) "We've heard this before." There have been repeated claims in the past that oil is running out, most recently in the 1970s, and none have come to pass. Each time, critics claim, price signals elicited new exploration and discoveries. However, current concerns are based on considerably more historical data and perspective, and better analytical tools and methods. In addition, there is no huge new Middle East resource waiting to be tapped as there was in the 1970-80s, and higher prices and increased drilling in recent years have yielded diminishing returns.

We wish to be careful about predicting when the peak and decline of world oil production will occur. While we don't believe it likely, it is possible the optimists are correct and the peak is 15 years away or longer. However, even if the optimists are correct and the world holds 3 trillion barrels of ultimately recoverable oil, at current rates of consumption and growth the peak would be delayed only a decade or slightly more.

Regardless when the peak occurs, the implications are so potentially profound, it would be prudent to begin mitigation efforts now. Robert Hirsch, co-author of the highly regarded report completed for the U.S. government, "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. … Mitigation efforts initiated earlier than required may turn out to be premature if peaking is long delayed. On the other hand, if peaking is imminent, failure to initiate timely mitigation could be extremely damaging."

Why Does It Matter? What Will Be the Impacts?

Oil and natural gas account for about two-thirds of U.S. energy use, with oil accounting for 40 percent and natural gas another 23 percent. Coal, which emits more heat-trapping carbon dioxide (CO_2) than oil or natural gas per unit of energy, accounts for another 22 percent, bringing total U.S. dependence on these fossil fuels to more than 85 percent.

Oil and natural gas are used in virtually everything we do – they underpin the majority of our economic activity. Personal and freight transportation are almost wholly dependent on oil. Between 7 and 15 percent of Oregon's electricity is generated by natural gas, depending on hydro conditions and nearly half our building space is heated by natural gas. Oil and natural gas are used for 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 clothing. As oil and gas become increasingly scarce and expensive, it will have profound implications for our economy and lifestyle.

One of the main charges of this task force is to identify the impacts of peak oil and natural gas in Portland, as a prelude to designing appropriate strategies to prepare for and mitigate the effects.

Will Coal, Nuclear, and Alternative Energy Sources Replace Oil and Natural Gas?

Many people think prices will stimulate technological improvements to replace declining oil and natural gas resources. The most common alternatives mentioned are nuclear, "clean" coal, oil sands, oil shale, hydrogen/fuel cells, and biofuels (biodiesel and ethanol), wind and solar.

Each of these is discussed briefly below. However, the overarching conclusion is that while some or all of these alternatives will be used in some measure, none of them, individually or in combination, are likely to be available in sufficient quantity to replace oil and natural gas in the quantities they are used today. 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. Oil and natural gas are the most concentrated energy sources known, with EROEIs typically 20-to-1 and greater. Fuels with lower EROEI would be less productive and, as a result, more expensive, which is why they have not been competitive with oil and natural gas to date. Fuels with an EROEI less than 1 take more energy to produce than they yield. More importantly, each of these alternatives will take at least a decade of development to replace significant amounts of oil or natural gas.

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 CO2 can be sequestered, but it requires 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 electricity only, 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- to 20-fold increase in nuclear power plant capacity would require massive infrastructure costs. With anything close to that many plants in operation, known reserves of uranium would be depleted within less than 20 years. Breeder reactors could prolong the lifecycle of nuclear power, 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 a low 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.

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 or nitrogen 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 porosity, 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 produce renewable energy systems. We need to begin building the infrastructure now while cheap oil and natural gas are still available, or they will be more expensive and difficult to make.

10) *Efficiency improvements* are a significant and necessary resource as well. They can reduce demand, which will make it easier for the resources above to meet our needs. Demand must decline, even as population continues to grow. While we cannot conserve our way to zero, we must significantly reduce the energy intensity of our economy.

If Alternative Energy Isn't Sufficient, What Is Required?

It is unlikely that the resources discussed above will displace oil and natural gas in the quantities with which they are currently used, at least within a few decades. In particular, peak oil presents a liquid fuels (i.e., transportation fuels) crisis. Major efficiencies are needed through redefining needs and reorganizing institutions. This may include lifestyle changes and adapting to expected impacts. Determining what those changes might be is one of the major charges of this task force.

Identifying Potential Impacts of Peak Oil and Natural Gas

One of the main charges to the Peak Oil Task Force is to identify the potential impacts of peak oil in Portland. Once the impacts are identified, it will be easier for the task force to target its recommendations for maximum effectiveness. The following section provides an introduction to some of the likely areas of impact, and to serve as a guide in developing a more in-depth analysis.

Some of the major impacts are quickly determined by reviewing where oil and natural gas are used directly. Virtually all transportation — surface, water, and air — are fueled by petroleum-based products. Natural gas heats half of Oregon homes and businesses, including most new homes, and is used to generate more than 7 percent of Oregon's electricity. Oil and natural gas provide process heat for various industrial processes, and about 10 percent of each fuel is used as feedstock to produce products, such as chemicals, fertilizer, asphalt and plastics. Price increases or cutbacks in key fuel resources will affect these activities. Impacts on these activities will vary depending on the ability to conserve, find substitutes, consolidate and re-prioritize activities. Impacts may also vary according to the percentage of a business operation's activities which are dependent on the fuel resource, although in many cases the fuel resource may be critical even at low percentages of the overall operation.

Other impacts may be secondary — that is, they may not depend directly on oil, but may depend instead on products or services that are impacted directly by the price or availability of oil. For example, as oil and natural gas become more expensive or less available, a larger share of personal incomes will go toward transportation and heating, and sales of other products and services may suffer. Alternatively, land use patterns may shift as businesses and residents relocate in response to problems with cost and availability of oil. This, in turn, may affect public services.

Below are some of the major areas which may experience impacts and questions intended to foster discussion. The task force is not anticipated to answer all of these questions but rather to assess which are the most relevant for Portland and illustrate the most significant local vulnerabilities.

Population Shifts

Will there be any mass movement of population? Will there be a movement toward denser urban areas to reduce travel, or will there be a movement toward rural areas to be closer to food? On a larger scale for Oregon, will there be widespread in-migration from other states?

Transportation

How will transportation modes and patterns be affected? Air transportation is likely to be one of the first sectors to be impacted by peak oil. How will that affect Portlanders? How will ports and intercontinental shipping be affected, and what will that mean for the economy in the Portland area? How will surface transportation be affected? Commuting? Inter-city and regional travel? Long-haul trucking? Intra-city trucking and distribution of goods? Warehousing and "just-in-time" delivery? Will rail, both long-haul and intra-city light rail, help minimize disruptions?

Land Use

In addition to population shifts, will there be other changes is how land is used? What will happen to regional malls and vehicle-oriented developments? Will there be increased pressure for mixed uses? How will neighborhoods be affected? Will some areas become depopulated? If so, what to do with them? What are the implications on roads, transportation, and traffic patterns? How about urban design?

Economic Impacts

Businesses can be affected in two primary ways: by how the price or availability of oil or natural gas impacts the product or service they provide, and by how it affects demand for their product or service among their customer groups. Economic activities which are non-essential, or those where oil and natural gas are critical resources which cannot easily be substituted or reduced, stand to be negatively impacted. For example, RV and long-vacations may be one of the first activities to be affected, as might the chemical industry which uses oil and natural gas as a feedstock for production. Other activities may maintain, still others may thrive. For planning purposes, which economic activities are at risk? What services or products unique to the region will be in high demand in an era of peak oil? What products or services provide a unique economic development opportunity for the region? How will heavy industry be affected? Light industry? Retail? Finance and insurance? Real estate? Construction? How will it affect land use, transportation, and housing patterns? What are the implications for employment? What can the city do to minimize the impacts in these areas?

Housing

How will housing and housing patterns be impacted? Will new construction be impacted as people opt to fix up existing homes? How will availability of construction materials be affected? Will people look for smaller housing in an attempt to reduce costs? Will there be a move toward infill development, or dividing large homes into smaller units? How will jobs in real estate and the construction trades be affected? Will upkeep and maintenance suffer as people spend more

on heating and transportation? Will homelessness increase? Are there particularly vulnerable demographic groups?

Food

The ability to transport food over long distances will be impacted. Also, price and availability of products which are highly dependent on fossil inputs (i.e., natural gas for fertilizers, oil for pesticides) will be significantly affected. For example, yields of corn, our largest crop, could drop from 130 bushels per acre today to 30 bushels per acre without fertilizer. These are just a few examples. What are the implications of this for Portland? How will food production change? Food processing? Long-distance transportation? Distribution? Storage and preservation? How will the price and availability of food be affected? Diet and nutrition? What are some potential problems if left unaddressed?

Public Services

Considering some of the possible population, economic, housing and land-use shifts, how will demand for public services such as water, sewer, police, and fire be affected? Will crime increase, decrease, or change in character? Will the need for fire protection increase if housing is poorly maintained? How will provision of these public services be affected? What are the implications on costs? How will these services be maintained? What if people can't afford to pay (i.e., water, sewer)? What are the consequences of reductions in services? (Transportation, planning, housing and social services are discussed in separate sections.)

Social Services

Based on some of the impacts identified from sectors discussed above, what will be the impact on social services? Will there be an increase in homelessness? Hunger? Shelter (heating)? Unemployment? The uninsured? How will this affect demand for housing assistance? Food assistance? Heating assistance? Health care for the poor and uninsured? Children services?

Health Services

How will the nature of illness and accidents requiring treatment be affected? How will health services be affected? How will it affect the model of care provided by health providers? Where are oil and natural gas, or oil and gas-based products, used in the health care system? How will price and availability of these products be affected? How will pharmaceuticals be affected? Sanitation? Emergency services? How will long-term care of the elderly, infirm, and disabled be affected? How will public health be affected? Would stress and other impacts on home heating and nutrition increase exposure to certain diseases? As impacts elsewhere require changes in housing, employment, recreation, etc., how will mental health be affected—will there be an increase in depression, panic, delusion, or other symptoms requiring treatment?

Education

What are the implications of peak oil for education? How will enrollment at individual schools be affected based on in- or out-migration? Will attendance at private schools increase or decrease? How will it affect the ability of the schools to provide busing? How will government revenues be affected? How will the curriculum be affected—i.e., how will job and career choices be affected (check with economic development/planning)? In terms of higher education,

how will it be affected? Will there be as many opportunities for college graduates? Which fields will remain critical (e.g., medicine)? Which may go by the wayside? How will this affect registration? How will affordability be affected? What will that mean for low- and middle-income students? Will there be an increased or decreased need for vocational training? In what fields?

Electricity

On the supply side, slightly more than 7 percent of Oregon's electricity is generated from natural gas. What will be the impact on electricity generation if natural gas is in short supply? On the demand side, what will be the impact? Will there be decreased demand because of stretched incomes, job loss, and impacts on other businesses? Or will electricity be called upon to pick up an added load now shouldered by oil and gas – for example, plug-in vehicles, residential customers switching to electric heat, industrial fuel switching? Will there be a net increase or decrease in demand? If a net increase is expected, how would utilities be able to meet the increased demand?

Manufacturing

Industry uses oil and natural gas both as a feedstock and to power various industrial processes. In some cases these may be critical resources—i.e., it may be difficult to find adequate alternatives. In other cases their supply/supplier may be at risk. In still others demand for their product may be affected. How will some of the key industries and industrial concerns in the area be affected by peak oil? What will that mean for jobs? Tax revenues?

Retail Business

Which kinds of retail businesses will be most affected by peak oil issues. Key candidates include food/groceries, clothing, electronics, appliances, cars, and housing supplies. How will the supply chain be affected? How will price or availability be affected? How will demand for the various products and services be affected if people have less discretionary income available? Will there be an increased demand for locally produced products? How will large chains stores fare relative to independent businesses? How will local artisans and craftspeople fare?

Communications

What are the implications for communications? What will be the effect on the microelectronics industry? How will chip production be affected? What does that imply for price, availability of computers? What about the cost of launching satellites? What about demand trends? As travel becomes more difficult or expensive, will demand for electronic communications increase (cellular, phone conferencing, video conferencing, etc.)? What are the implications of these supply/demand trends?

Construction

How will construction and real estate be affected? The answers to this will be related to what the impacts will be on the housing sector (above). For example, will there be a shift from new construction to remodeling? How much activity, whether new construction or remodeling, will likely be affected by how economically stretched homeowners are. Some sub-trades may fare

better than others. For example, re-roofing may take precedence to other remodels if/when incomes are tight.

Finance

What will happen to interest rates? Will there be an increase in defaults? What will happen with deposits? How will investments be affected? How will people's net assets be affected as a result? How will it impact pension funds? How will municipal bonds be affected?

Professional Services

How will demand for some of the key professional services be affected, such as architecture, law, accounting, and engineering? Others?