UPPSALA UNIVERSITET

Institutionen för strålningsvetenskap

Kjell Aleklett
Professor i fysik

Besöksadress:
Ångströmlab. 12235
Lägerhyddsvägen 1

Postadress:
Box 535
751 21 Uppsala

Telefon:
018 - 471 5825
070 - 425 0604

Telefax:
018 - 471 3513

Epost:
Aleklett@tsl.uu.se

Department of radiation sciences
Division of nuclear physics
Kjell Aleklett
Professor in physics

Visiting address:
Ångströmlab. 12235
Lägerhyddsvägen 1

Postal address:
Box 535
SE-751 21 Uppsala
SWEDEN

Telephone:
+46 18 - 471 5825
+46 70 - 425 0604

Telefax:
+46 18 - 471 3513

E-Mail:
Aleklett@tsl.uu.se

Uppsala 6th March 2006

Roxane Le Guen
Secretary, Senate Rural and Regional Affairs and Transport Committee
Department of the Senate, Parliament House,
Canberra ACT 2600

Dear Roxane,

On behalf of ASPO-International, I would like to offer this submission to the very important Senate inquiry into Australia's future oil supplies.

The Association for the Study of Peak Oil & Gas is an international network of scientists mostly affiliated with European institutions and universities, working to determine the date and impact of the peak and decline of the world's production of oil and gas, due to resource constraints.

ASPO had its origins in Germany. In late 2000 Colin J. Campbell gave a talk on oil depletion at the ancient university of Clausthal in the Harz Mountains. The idea developed of forming an institution or network of scientists concerned about the subject. Dr Campbell took the idea to Professor Wellmer, the head of the BGR in Hannover, who gave it his support. The Norwegians were the next to join, followed by the Swedes.

The next step forward came when I organised the first International Workshop on Oil Depletion in Uppsala in May of 2002, to be followed by workshops in Paris, Berlin and Lisbon. Today, ASPO has members in Austria, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Switzerland, Sweden and the United Kingdom. ASPO has briefed industry and government in Europe, the USA and Australia.

I was invited to appear before a US House of Representatives Hearing *"Understanding the Peak Oil Theory"* in December 2005, and I offer a copy of my testimony for the Committee's consideration as an important part of my submission. Peak Oil is a global problem, so the risks of Peak Oil, and the mitigation and adaptation strategies urgently necessary are broadly similar across the developed world. On my recent Australian visit to launch ASPO-Australia I certainly noticed many similarities between the US and Australia. As well, I include copies of my article in the recent World Watch Institute Peak Oil Forum published in Washington in January 2006 and two of the other papers.

I urge the Senate and the Australian Government to give very serious consideration to Peak Oil. We should have started at least 10 years ago. We must act now, as otherwise the bumps and holes in the road might be devastating.

Yours sincerely,

Kjell Aleklett, Professor
President, ASPO
www.PeakOil.net

Published on 10 Dec 2005 by US House of Representatives. Archived on 10 Dec 2005.

Aleklett: Testimony on Peak Oil to US Congress

by Kjell Aleklett, President of ASPO

The following testimony was given on the 7th December 2005 to the Committee on Energy and Commerce in a hearing entitled Understanding the Peak Oil Theory in the US House of Representatives:

Mr. Chairman, ladies and gentlemen on the committee:

I thank the Committee for this opportunity to discuss Peak Oil and the work of Uppsala Hydrocarbon Depletion Study Group, Uppsala University, Sweden. We are also members in the network of ASPO, the Association for the Study of Peak Oil and Gas, and I'm since 2003 president of ASPO. Members of ASPO, including the ASPO-USA affiliate, have an interest in determining the date and impact of the peak and decline of the world's production of oil and gas, due to resource constraints (www.peakoil.net).
The mission is to:
1. Define and evaluate the world's endowment of oil and gas.
2. Model depletion, taking due account of demand, economics, technology and politics.
3. Raise awareness of the serious consequences for Mankind.

I like to summarize the global situation for Peak Oil the following way: When I was born in 1945, none of the four small farms in my little Swedish village used oil for anything. Ten years later, the oil age had arrived: we had replaced coal with oil for heating, my father had bought a motorcycle, and tractors were seen in the fields. From 1945 to 1970, Sweden increased its use of energy by a factor of five, or nearly 7 percent per year for 25 years. This journey into the oil age transformed Sweden from a rather poor country into the third wealthiest country (per capita) in the world. Ninety percent of the energy increase came from oil. Cheap oil made Sweden rich.

Now consider China, a developing country with 21 percent of the global population. It consumes 8 percent of the global oil supply, and thinks it is fair to claim 21 percent of daily global consumption, or 17.6 million barrels per day (mbpd). During the last five years the average annual GDP growth in China has been 8.2 percent and the average increase in oil consumption 8.4 percent per year. We can now see the same correlation between increase in GDP and use of oil in China as in Sweden 50 years ago. If China's economy grows 8 percent per year over the coming five years, we can expect that it will need an increase in the consumption of oil of 3 million barrels per day by 2010. According to Professor Pang Xiongqi at the China University of Petroleum in Beijing, China's production will plateau in 2009 and then start to decline. This means that the total increase in consumption must be imported. As China is already importing 3 million barrels per day, it will have to increase imports 100 percent during the next five years. Where will it come from?

Since 2001, when ASPO was founded, we have tried to tell the world that there will soon be a problem supplying the world with crude oil while demand continues to rise. The estimated peak-production year at the first depletion workshop in Uppsala in 2002 was 2010. Two years later at our Berlin meeting it had moved to 2008, and now it looks like we are back to 2010, because production from deepwater oil fields will yield more than we expected. The exact year for peak oil depends very much on future demand and we will not know when we have peaked until we have crossed the threshold. It will certainly happen before 2020.

Unfortunately, few have heeded our alerts, even though the signs have been so obvious that a blind hen could see them. Fifty years ago the world was consuming 4 billion barrels of oil per year and the average discovery rate (the rate of finding undiscovered oil fields) was around 30 billion barrels per year. Today we consume 30 billion barrels per year and the discovery rate is dropping toward 4 billion barrels per year (see figure 1). This is significant; Chevron is even running an ad saying, "The world consumes two barrels of oil for every barrel discovered." (By discovery, I mean only new oil fields. Some analysts include reserve growth—newly accessible oil in old fields—as new discoveries, but we are using the same approach as in World Energy Outlook 2004, IEA, International Energy Agency)

If we extrapolate the downward discovery slope from the last 30 years in figure 1, we can estimate that about 135 billion "new" barrels of oil will be found over the next 30 years. The latest large oil field system to be found was the North Sea (in 1969), which contains about 60 billion barrels. In 1999 the North Sea field production peaked at 6 mbpd. Our extrapolation suggests that over the next 30 years we will discover new oil fields equal to twice the size of the North Sea—a very pessimistic prediction, according to our opponents. But I think the oil industry would be ecstatic to find two new North-Sea-size oil provinces.

The World Energy Outlook 2005 base-case scenario projects that by 2030 global oil demand will be 115 million barrels per day, which will require increasing production by 31 million barrels per day over the next 25 years, of which 25 mbpd is predicted to come from fields that have yet to be discovered. That is, we'll have to find four petroleum systems of the size of the North Sea. Is this reality?

Every oilfield reaches a point of maximum production. When production falls advanced technologies can reduce but not eliminate the decline. The oil industry and the IEA accept the fact that the total production from existing oil fields is declining. ExxonMobil informed shareholders that the average production decline rate for the global oil fields are between 4 and 6 percent per year (The Lamp, 2003, Vol85, No1). Current global production is 84 million barrels per day, so next year at this time current fields may produce a total of roughly 80 million barrels per day. Given the expected increase in global GDP, one year from now total oil demand will be 85.5 mbpd—so new capacity might have to make up for 1.5 mbpd plus 4 mbpd, or 5.5 mbpd. Two years from now the needed new production will be 11 mbpd and in 2010 at least 25 mbpd. Can the industry deliver this amount? If we extend the decline in existing fields through 2030, and accept the 2004 scenario by the Energy Information Administration (global demand of 122 mbpd), then "we need new production that is of the order of 10 new Saudi Arabias." Some might call this a doomsday scenario, but if so I'm not the doomsayer—it's Sadad Al Husseini, until recently vice-director of Saudi Aramco, the largest oil company in the world.

Excluding deepwater oilfields, output from 54 of the 65 largest oil-producing countries in the world is in decline. Indonesia, a member of the Organization of Petroleum Exporting Countries (OPEC), not only can't produce enough oil to meet its production quota, it can't even produce enough for domestic consumption. Indonesia is now an oil importing country. Within six years, five more countries will peak. Only a few countries—Saudi Arabia, Iraq, Kuwait, United Arab Emirates, Kazakhstan, and Bolivia—have the potential to produce more oil than before. By 2010, production from these countries and from deepwater fields will have to offset the decline in 59 countries and the increased demand from the rest of the world.

Can they do it? Let's look at Saudi Arabia, which in the early 1980s produced 9.6 million barrels per day. According to the IEA and the EIA Saudi Arabia must produce 22 mbpd by 2030. But Sadad Al Husseini claims that "the American government's forecasts for future oil supplies are a dangerous over-estimate." The Saudi Ghawar oil field, the largest in the world, may be in decline (see for example the book “Twilight in the dessert” by Mathew Simmons). Saudi Aramco says that production can be increased to 12.5 mbpd in 2015. They plan a new pipeline with a capacity of 2.5 mbpd, so it looks like they are willing to increase production to 12.5 mbpd, but so far there are no signs of reaching 22 mbpd.

Now consider Iraq, which in 1979 produced 3.4 mbpd. Iraq officially claims reserves of 112 billion barrels of crude oil, but ASPO (and other analysts) think that one-third of the reported reserves are fictitious "political barrels." At a recent meeting in London, I was told (privately, by a person who is in a position to know) that Iraqi reserves available today for production total 46 billion barrels. If this is the case, it will be hard for Iraq to reach its former peak production level in a short time.

And so on. It's time to ask, can the Middle East ever again produce at the peak rates of the 1970s?

Many countries in the world are very poor. It may be necessary to double global GDP to achieve any kind of decent life for people in these countries. The examples of Sweden and China suggest that, if past economic development patterns are followed, doubling GDP will require doubling global oil production. Can this even be done?

The United States, the wealthiest country in the world, has 5 percent of the global population and uses 25 percent of the oil. It is time to discuss what the United States should do to cut consumption—and rapidly. In February 2005 a report for the U.S. Department of Energy, DoE, (Peaking of World Oil Production: Impacts, Mitigation, & Risk Management) argued that "world oil peaking represents a problem like none other. The political, economic, and social stakes are enormous. Prudent risk management demands urgent attention and early action." Any serious program launched today will take 20 years to complete.

What about oil sands? The enormous reserves of oil sands in Canada are often mentioned as a lifesaver for the world. The report to DoE in February inspired us to undertake a “Crash Program Scenario Study for the Canadian Oil Sand Industry” (B. Söderbergh, F. Robelius, and K. Aleklett, to be published). In the study we found that Canada must very soon decide if its natural gas should be exported to USA or instead used for the oil sands industry. In a short-term crash program the maximum production from oil sands will be 3.6 million barrels per day in 2018. This production cannot offset even the combined decline of just the Canadian and North Sea provinces (see Fig.2). A long-term crash program would give 6 million barrels by 2040, but then new nuclear power plants would be needed to generate steam for the in-situ production.

In view of the importance of the world's future energy supply, The Royal Swedish Academy of Sciences (the Academy that awards the Nobel Prizes in physics, chemistry, and The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel) has recently established an Energy Committee. The Academy is an independent non-governmental organization, with expertise in most of the sciences as well as economic, social, and humanistic fields. The Energy Committee has selected a number of subjects to be studied in some depth and one of these deals with oil and related carbon-based fuels. The Academy organized hearings and a seminar before subsequently (on October 14, 2005) issuing a statement about oil (the full statement can be found at the end of this text). I'll note just one excerpt from the general remarks: "It is very likely that the world is now entering a challenging period for energy supply, due to the limited resources and production problems now facing conventional (easily accessible) oil.”

From figure 1 we can conclude that the peak of global discovery of oil was around 1960. In figure 3 we have a well-defined discovery peak for US Lower 48. This peak defines how much can be produced and Peak Oil for the region was 35 years later in 1971. Based on the assumption that we only can consume the oil we have already found and expect to find, we have predicted oil production in the future for the world till 2050 (figure 4). Deep water is the latest oil-production frontier. During the coming years a number of large fields will come into production, and we believe that the peak production from these fields will define the upper time limit for peak oil. Based on the data available today, we can expect global Peak Oil in 2010, with a few years uncertainty.

Animals that face food shortages have a hard time adjusting and usually their populations decline. Some believe that we as human beings will face a similar situation. I can't accept that. As human beings we can think and come up with ideas, and I believe we can find solutions. The road will be bumpy and many people will be hurt, but when we arrive at the end of this road, it must be as a sustainable society. It will not be possible to travel this road without using part of the existing stocks of fossil fuels and, for industrial countries, nuclear energy as well, but we can do it in a manner that will have minimal impact on the planet. The problem is that we should have started at least 10 years ago. We must act now, as otherwise the bumps and holes in the road might be devastating.

Kjell Aleklett, Professor in Physics

Uppsala University, Box 535
SE-751 21 Uppsala, Sweden
E-mail: Aleklett@tsl.uu.se
Tel: +46 70425 0604

Association for the Study of Peak Oil and Gas: www.peakoil.net
Association for the Study of Peak Oil and Gas - USA: www.aspo-usa.com

Figures:

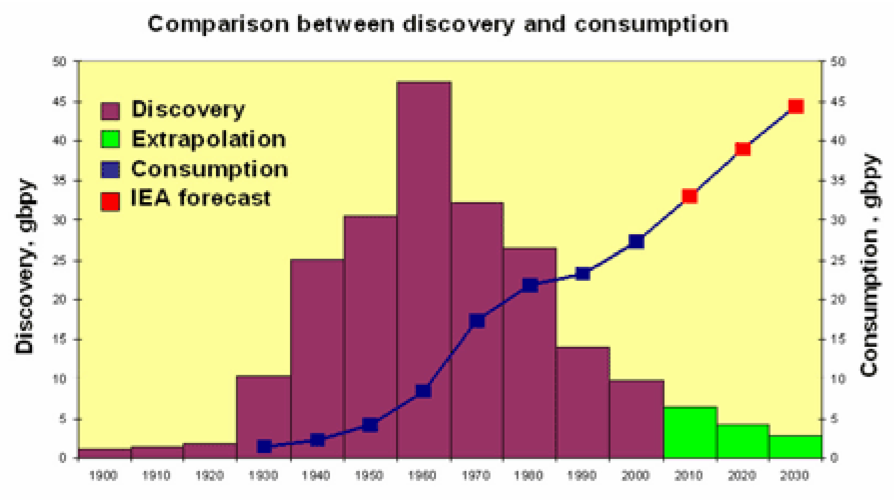

Figure 1: Discovery of conventional oil and extrapolation of future discoveries and consumption of conventional oil and predicted consumption according to IEA. The number for year 2000 is the average number for the years 1995 to 2004, etc. (K. Aleklett, www.peakoil.net)

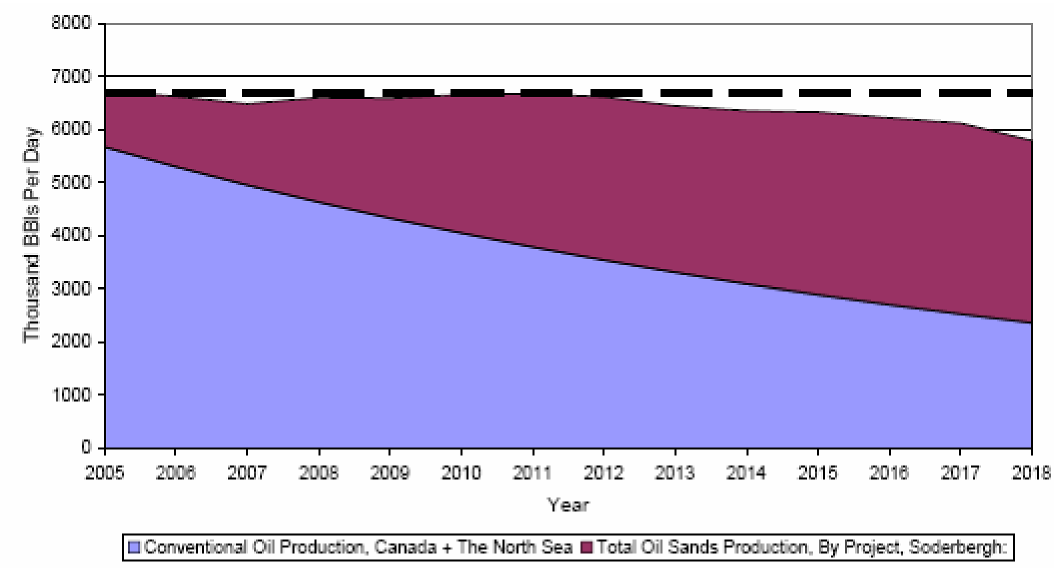

Fig 2. Canadian Conventional + The North Sea + Canadian Oil Sands Crash Program Crude Oil Production 2005 – 2018 (B. Söderbergh, F. Robelius, and K. Aleklett, to be published)

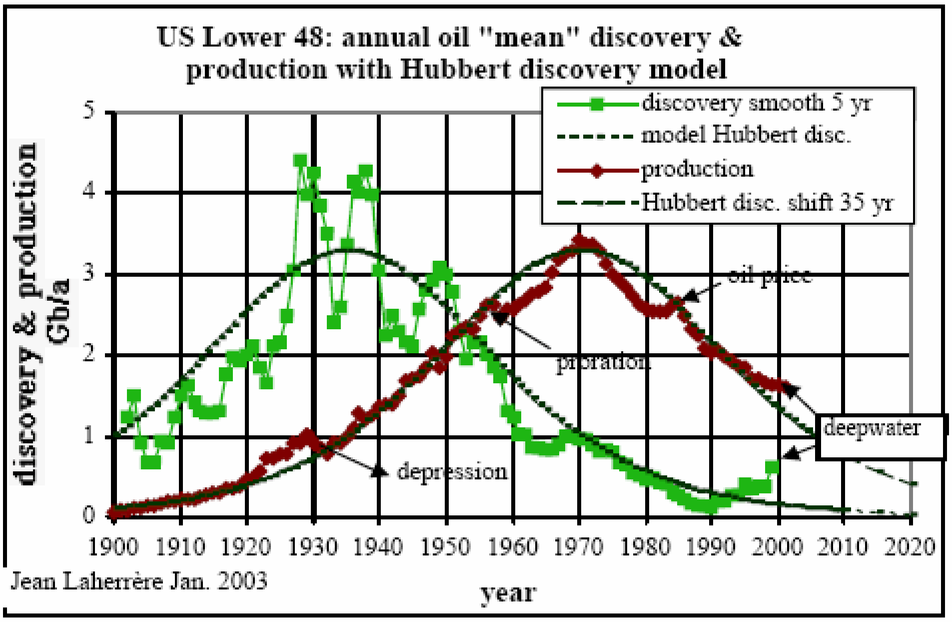

Figure 3: Annual discovery and production of oil in US lower 48 states. (Jean Laherrère, January 2003.)

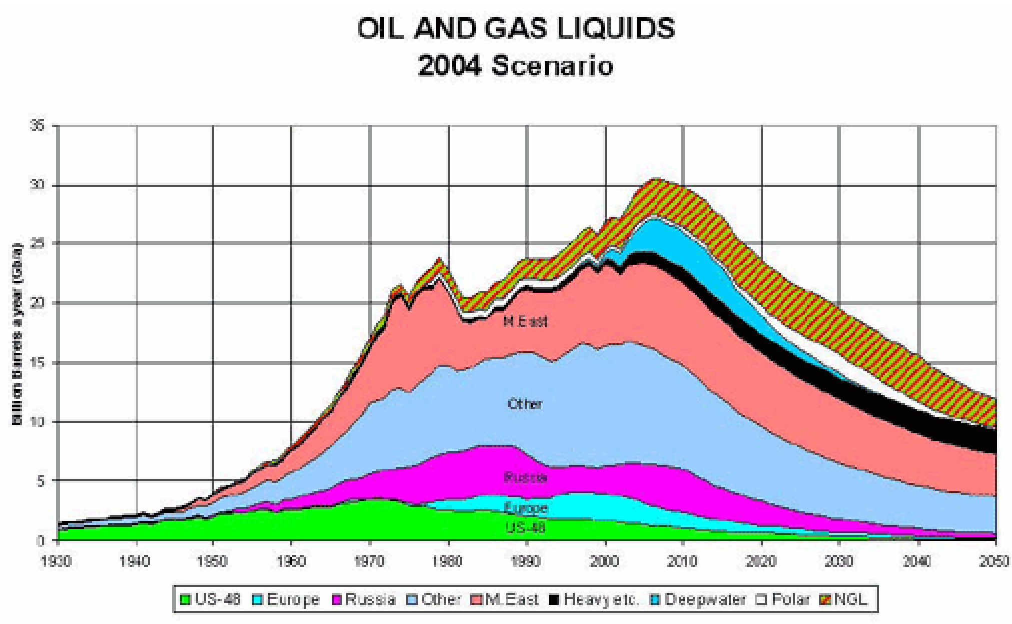

Figure 4: Oil and gas liquids scenario (updated from K. Aleklett and C.J. Campbell, Minerals & Energy, 2003; 18:5-20)

WORLD·WATCH

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Peak Oil Forum

Excerpted from the January/February 2006 WORLD WATCH magazine

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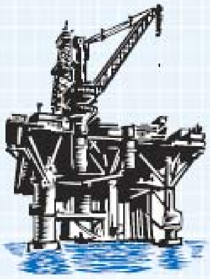


Peak Oil Forum

The world now has over a century's intense experience with oil, the most prized form of energy ever. Oil's benefits are many and undeniable. It accounts for one-third of global energy use and underpins the modern industrial way of life.

But oil is also in crisis. Its long-standing dangers to climate, land use, and human social structures are partly to blame. (If shown the big picture, would our ancestors have paused before rushing into the oil age? Groundwork, p. 30, discusses the precautionary principle.) But the crisis has a new element: we are about to discover what life is like without cheap and abundant petroleum. Global oil production is nearing its peak.

Only a few months ago, the concept of a maximum rate of global oil production was fresh enough to be startling, at least to nonspecialists. Now it is no longer in question among most experts, no matter what point on the spectrum they hail from. The only questions are when the peak will arrive—current estimates seem to be converging on 2010–2020—and what we ought to be doing about it.

On that score, there is considerable argument. The five experts featured here are moderates compared with those who foresee an apocalypse within a year or two, or 10 at the most. While no one can know what 2015 will be like, it's worth remembering that some people find the prospect of civilizational collapse deliciously fascinating.

Our five experts' positions probably bracket the truth. The one unavoidable fact is that oil, a finite resource, cannot *economically* be pumped out of the ground forever. The approaching peak is a wake-up call. What happens—not when oil runs out, which it never will—but when it becomes very expensive? When we must decide how to allocate this increasingly precious commodity among the many competing uses—transportation, agriculture, the countless artifacts of everyday life—upon which the industrialized world is built?

The transition has begun. As one expert put it at a recent conference, "If the oil age were a party and we went with a six-pack, then we've drunk four beers already." Production from existing fields is dropping about 5 percent per year. Only one barrel of oil is now being discovered for every three or four consumed. Globally, the discovery rate of untapped oil peaked in the late 1960s, and experience with individual fields and oil provinces suggests that peak production lags behind peak discovery by 25–45 years.

So what's the prudent course? The recent history of renewables' growth proves that our energy future is policy driven. On that score, the U.S. government is close to reactionary, but even its own analysis (the "Hirsch Report") has said that we need at least a decade's head start if we want to mitigate the effects of an oil production decline. That means we should be starting…now.

—Tom Prugh, *Editor*

For more information about issues raised in this story, visit **www.worldwatch.org/ww/peakoil/**.

Oil: A Bumpy Road Ahead

By Kjell Aleklett

When I was born in 1945, none of the four small farms in my little Swedish village used oil for anything. Ten years later, the oil age had arrived: we had replaced coal with oil for heating, my father had bought a motorcycle, and tractors were seen in the fields. From 1945 to 1970, Sweden increased its use of energy by a factor of five, or nearly 7 percent per year for 25 years. This journey into the oil age transformed Sweden from a rather poor country into the third wealthiest country (per capita) in the world. Ninety percent of the energy increase came from oil. Cheap oil made Sweden rich.

Now consider China, a developing country with 21 percent of the global population. It consumes 8 percent of the global oil supply, and thinks it is fair to claim 21 percent, or 17.6 million barrels per day (mb/d). During the last five years the average annual GDP growth in China has been 8.2 percent and the average increase in oil consumption 8.4 percent per year. We can now see the same correlation between increase in GDP and use of oil in China as in Sweden 50 years ago. If China's economy grows 8 percent per year over the coming five years, we can expect that it will need an increase in the consumption of oil of 3 million barrels per day. According to Professor Pang Xiongqi of the China University of Petroleum in Beijing, China's production will remain level till 2009 and then start to decline. This means that the total increase in consumption must be imported. As China is already importing 3 million barrels per day, it will have to increase imports 100 percent during the next five years. Where will it come from?

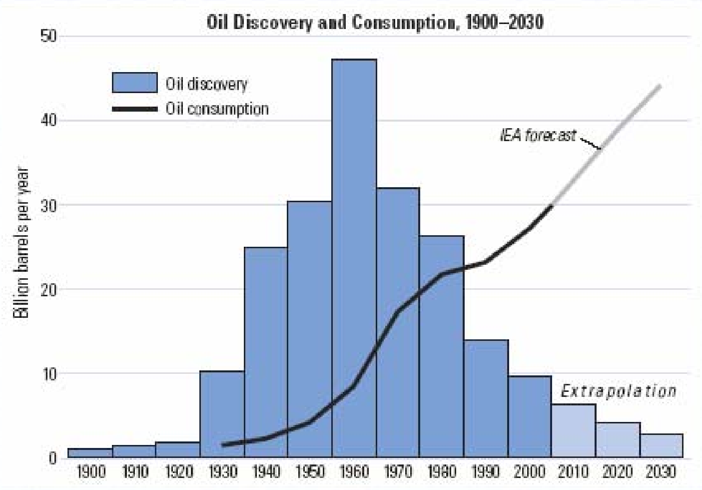
Since 2001, when the Association for the Study of Peak Oil & Gas (ASPO) was founded, we have tried to tell the world that there will soon be a problem supplying the world with crude oil while demand continues to rise. The estimated peak-production year at the first depletion workshop in Uppsala in 2002 was 2010. Two years later at our Berlin meeting it had moved to 2008, and now it looks like we are back to 2010, because production from deepwater oil fields will yield more than we expected. The exact year for peak oil depends very much on future demand and we will not know when we have peaked until we have crossed the threshold. It will certainly happen before 2020.

Unfortunately, very few have heeded our alerts, even though the signs have been so obvious that a blind hen could see them. Fifty years ago the world was consuming 4 billion barrels of oil per year and the average discovery rate (the rate of finding undiscovered oil fields) was around 30 billion barrels per year. Today we consume 30 billion barrels per year and the discovery rate is dropping toward 4 billion barrels per year (see figure, p. 12). This is significant; Chevron is even running an ad saying, "The world consumes two barrels of oil for every barrel discovered. So is this something you should be worried about?" (By discovery, I mean only new oil fields. Some analysts include reserve growth—newly accessible oil in old fields—as new discoveries, but we are using the same approach as IEA, the International Energy Agency.)

If we extrapolate the downward discovery slope from the last 30 years, we can estimate that about 134 billion "new" barrels of oil will be found over the next 30 years. The latest large oil field system to be found is the North Sea (in 1969), which contains about 60 billion barrels. In 1999 the North Sea field production peaked at 6 mb/d. Our extrapolation suggests that over the next 30 years we will find new oil fields equal to twice the size of the North Sea—a very pessimistic prediction, according to our opponents. But I think the oil industry would be ecstatic to find two new North-Sea-size oil provinces.

The IEA's 2004 base-case scenario projects that by 2030 global oil demand will be 121 million barrels per year, which will require increasing production by 37 million barrels per day over the next 25 years, of which 25 mb/d is predicted to come from fields that have yet to be discovered. That is, we'll have to find four petroleum systems the size of the North Sea. Is this reality?

Every oilfield reaches a point of maximum production, which advanced technologies can delay or extend, but not eliminate. The oil industry and IEA accept the fact that the total production from existing oil fields is declining. According to ExxonMobil, the average production decline rate is between 4 and 6 percent per year. Current global production is 84 million barrels per day, so next year at this time all current fields will produce a total of roughly 80 million barrels



per day. Given the expected increase in global GDP, one year from now total oil demand will be 85.5 mb/d—so new capacity will have to make up for 1.5 mb/d plus 4 mb/d, or 5.5 mb/d. Two years from now the needed new production will be 11 mb/d and in 2010 at least 25 mb/d. Can the industry deliver? If we extend the decline in existing fields through 2030, and accept the IEA base-case scenario (global demand of 121 mb/d), then "we need new production that is of the order of 10 new Saudi Arabias." Some might call this a doomsday scenario, but if so I'm not the doomsayer—it's Sadad Al Husseini, until recently vice-director of Saudi Aramco, the largest oil company in the world.

Excluding deepwater oilfields, output from 54 of the 65 largest oil-producing countries in the world is in decline. Indonesia, a member of the Organization of the Petroleum Exporting Countries (OPEC), not only can't produce enough oil to meet its production quota, it can't even produce enough for domestic consumption. Indonesia is now an oil importing country. Within six years, five more countries will peak. Only a few countries—Saudi Arabia, Iraq, Kuwait, United Arab Emirates, Kazakhstan, and Bolivia—have the potential to produce more oil than before. By 2010, production from these countries and from deepwater fields will have to offset the decline in 59 countries and the increased demand from the rest of the world.

Can they do it? Let's look at Saudi Arabia, which in the early 1980s produced 9.6 million barrels per day. According to the IEA and the U.S. Energy Information Administration, Saudi Arabia must produce 22 mb/d by 2030. But Sadad Al Husseini claims that "the American government's forecasts for future oil supplies are a dangerous over-estimate." The Saudi Ghawar oil field, the largest in the world, is in decline. Saudi Aramco says that production can be increased to 12.5 mb/d in 2015. They plan a new pipeline with a capacity of 2.5 mb/d, so it looks like they are willing to increase production to 12.5 mb/d, but so far there are no signs of reaching 22 mb/d.

Now consider Iraq, which in 1979 produced 3.4 mb/d. Iraq officially claims reserves of 112 billion barrels of crude oil, but ASPO (and other analysts) think that one-third of the reported reserves are fictitious "political barrels." At a recent meeting in London, I was told (privately, by a person who is in a position to know) that Iraqi reserves available today for production total 46 billion barrels. If this is the case, it will be hard for Iraq to reach its former peak production level in a short time.

And so on. It's time to ask, can the Middle East ever again produce at the peak rates of the 1970s?

Many countries in the world are very poor. It may be necessary to double global GDP to achieve any kind of decent life for people in these countries. The examples of Sweden and China suggest that, if past economic development patterns are followed, doubling GDP will require doubling global oil production. Can this even be done? And can the planet tolerate the increase in CO_2 emissions?

The United States, the wealthiest country in the world, has 5 percent of the global population and uses 25 percent of the oil. It is time to discuss what the United States should do to cut consumption—and rapidly. In February 2005 a report for the U.S. Department of Energy (*Peaking of World Oil Production: Impacts, Mitigation, and Risk Management*, aka the Hirsch Report) argued that "world oil peaking represents a problem like none other. The political, economic, and social stakes are enormous. Prudent risk management demands urgent attention and early action." Any serious program launched today will take 20 years to complete.

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Kjell Aleklett *is Professor of Physics at Uppsala University, Sweden, and President of the Association for the Study of Peak Oil & Gas.*

Over the Peak

By Christopher Flavin

As oil prices soared from $24 per barrel in early 2003 to a peak of $70 per barrel in September 2005, the question being asked by experts and policy makers alike was whether we've "entered a new era," as Chevron Corporation CEO David O'Reilly has said, or just encountered a temporary glitch that will be corrected by market forces, as ExxonMobil President Rex Tillerson argued in a speech to the World Petroleum Congress last September.

The most intriguing thing about this raging debate over whether oil production will soon peak—and put an end to the go-go days of the petroleum age—is that it's occurring at all. The fact that a century into the age of oil, and with the global economy dependent on $3 trillion worth of this black liquid each year, we don't know how much is left, is extraordinary.

It turns out that most of the forecasters who are responsible for the long-term energy projections on which private and public decision makers rely—from Wal-Mart to the International Energy Agency—have been on automatic pilot, assuming that whatever the future level of demand, the oil companies will be able to extract sufficient oil to meet it. You don't have to be a card-carrying member of the "peak oil" school that has gathered behind former Shell geologist Colin Campbell to see that this is a dangerous assumption.

One fact is undeniable: over the past decade, oil production has been falling in 33 of the world's 48 largest oil producing countries, including 6 of the 11 members of OPEC. In the continental United States, the world's oil pioneer, production peaked 35 years ago at 8 million barrels per day, falling to less than 3 million barrels per day now. Among the other major oil-producing countries where production is declining are the United Kingdom and Indonesia.

Those who take a more sanguine view of the global oil prospect point to the 1.1 trillion barrels of "proven" reserves that are currently on the books of the world's oil companies—equivalent to all the oil extracted over the past century, or more than 40 years of consumption at the current rate. Although those same figures appear in most official oil reports, it turns out that roughly three-quarters of the world's oil is controlled by state-owned companies, whose reserve figures are never audited and are based as much on politics as on geology. Many countries have added paper barrels to their reserves at times they weren't even looking for oil.

Since oil can't be extracted unless it is found, one of the most persuasive arguments that oil production is nearing its peak is that oil extraction has exceeded discoveries by a factor of three during the past two decades. This is clearly a trend that cannot continue. PFC Energy, an oil industry consulting firm, has recently analyzed these figures and concluded that non-OPEC oil production will peak within five years, and that OPEC production could peak within another five years. Chevron Corporation is among those that have argued that nearly half the world's exploitable oil has already been extracted.

The largest wild card facing the future of oil is the Middle East, where highly secretive state-owned companies have kept silent on the condition of their vast oil fields for the last 30 years. Contrary to the popular myth that their oil resources are so vast as to flow freely from the Earth wherever a hole is punched, papers published by Saudi engineers indicate that massive water injection and other forms of secondary recovery are now needed to keep the oil flowing. A handful of 30–50-year-old oil fields supplies most of the nearly 10 million barrels of oil that Saudi Arabia produces each day, and hardly any new fields have been discovered in the last two decades. Late last year, U.S. intelligence analysts questioned whether Saudi Arabia can even meet its near-term pledge to raise production modestly, let alone achieve the massive increases that many oil-consuming countries appear to be counting on.

Those who live by the crystal ball often end up eating ground glass, so I won't join those in the peak oil school who have predicted which month world oil production will peak. But there's one conclusion on which I'm ready to stake my reputation: the current path—continually expanding our use of oil on the assumption that the Earth will yield whatever quantity we need—is irresponsible and reckless.

The first step in getting off that path is to agree that far greater transparency is needed on the part of oil-exporting companies and governments. Just as commercial aircraft cannot land at international airports unless they meet accepted

Jim Wark/Peter Arnold, Inc.

Oil wells in a California vineyard

safety standards, and companies must meet accounting standards to be listed on stock exchanges, those who sell oil internationally should have their reserves regularly monitored by outside experts—as is already required of the large private companies such as ExxonMobil and Shell.

On the question of what can be done to reduce dependence on oil, I part company with some of the peak oil advocates—particularly those with an apocalyptic bent who are predicting an end to civilization as we know it. While it is undeniable that oil is central to the modern economy and that a peak in oil production would be a shock, human societies have created new energy systems before. And if we have to, we will do so again.

The same technological revolution that created the Internet and so many other 21st-century wonders can be used to efficiently harness the world's vast supplies of wind, biomass, and other forms of solar energy—which are 6,000 times greater on an annual basis than the fossil resources we now rely on. Technologies such as solar cells, fuel cells, biorefineries, and wind turbines are in about the same place today that the internal combustion engine and electromagnetic generator occupied in 1905. These key enabling technologies have already been developed and commercialized, but they are just now entering the world's largest energy markets.

Thanks to a potent combination of advancing technology and new government policies, those markets are now shifting. Since 2000, world biofuels production has grown at an 18-percent annual rate, wind power at 28 percent per year, and solar power at 32 percent per year. During the same period, the use of oil has grown at less than 2 percent annually. Roughly $30 billion was invested in advanced biofuels, giant wind farms, solar manufacturing plants, and other technologies in 2004, attracting companies such as General Electric and Shell to the fastest growing segment of the global energy business.

As with everything from automobiles to cell phones, mass production is driving down the cost of renewable energy, which is beginning to attract the same kind of buzz that surrounded John D. Rockefeller's feverish expansion of the oil industry in the 1880s—or Bill Gates's early moves in the software business in the 1980s. Indeed, in the last year, new energy technologies have been almost as popular with Silicon Valley venture capitalists as the latest Internet software.

These "new renewables" now provide just 2 percent of the world's energy, but as the computer industry discovered decades ago, double-digit growth rates can rapidly turn a tiny sector into a giant. Brazil already gets over 40 percent of its light transportation fuel from ethanol derived from sugar cane, and studies in the United States indicate that this largest of all oil consumers could grow well over half its liquid fuels using advanced new technologies that are expected to be commercialized in the next decade.

None of this is to say that the transition away from oil will be easy. Energy prices are likely to rollercoaster in the years ahead, disrupting the world economy, and making it difficult to smoothly plan the development of alternatives. But crises often create opportunities, and the potential rewards from an energy transition are substantial indeed: creating whole new industries, particularly in developing countries; reviving agricultural markets and strengthening rural economies; and pinching off the money pipeline that is destabilizing the Middle East.

But there is another danger surrounding a potential peak in world oil production: the impact on global warming. Some have argued that a forced march away from oil will push the world economy into dependence on fuels that add even more carbon dioxide pollution to the atmosphere: oil shale, tar sands, and coal, all of which are extremely abundant—and dirty.

That danger is real. High oil prices make it more economical to turn these carbon-based fuels into liquids, and if they receive heavy subsidies while the cleaner alternatives are starved, we may be facing an ecological crisis as well as an economic one. On the other hand, if rising oil prices give a serious boost to investment in energy efficiency, public transportation, biofuels, and other renewable energy sources, they could jumpstart the energy transition that is needed to solve the climate emergency now facing the world.

One point is inarguable: a century after the oil age began in earnest, humanity faces an historic test. Human ingenuity is one resource that won't peak—but whether it can be mobilized quickly enough to surmount these challenges is not yet clear.

Christopher Flavin *is President of the Worldwatch Institute.*

Planning for the Peak in World Oil Production

By Robert K. Kaufmann

You will never wake to the headline, "World Runs Out of Oil." Rather, global oil production will rise, reach one or more peaks, and decline. Well before production declines to very low levels, the peak will mark a point of no return that will be a watershed in the economic history of the 21st century. For the first time, industrial economies will be forced to a lower-quality energy source. And this decline will affect every aspect of modern life.

The notion of a world speeding towards a peak in oil production was made famous by the geologist M. King Hubbert. In the late 1950s and early 1960s, Hubbert used a simple bell-shaped curve to forecast the annual rate of production in the lower 48 U.S. states (see figure). At a time when oil production was increasing rapidly, Hubbert forecast that it would peak in about a decade (1965–1970) and decline thereafter. Despite provoking nearly unanimous derision, his forecast was remarkably accurate. Oil production peaked in 1970 and declined fairly steadily thereafter. A similar bell-shaped pattern appears in several other oil producing nations, such as Norway, the United Kingdom, and Egypt.

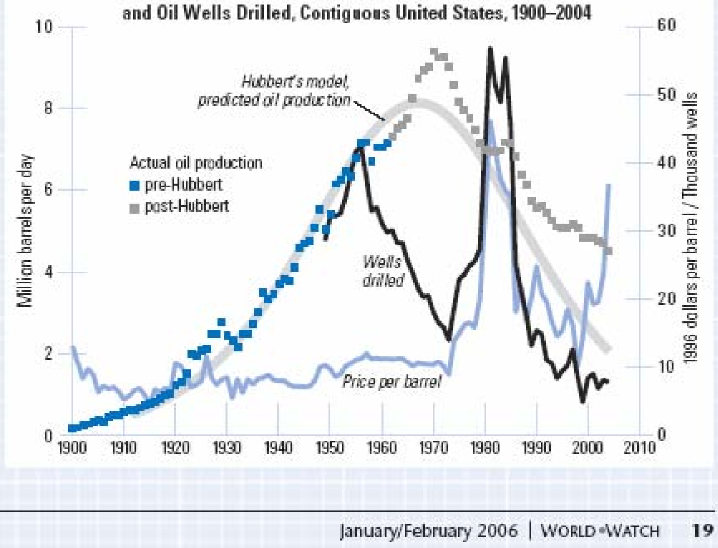
Subsequent research indicates that Hubbert's forecast was part genius and part luck. U.S. oil production is determined by the costs of production, the price of oil, and the quantity of oil "shut in" by the Texas Railroad Commission, which aimed to stabilize prices by opening and closing oil wells in Texas to ensure a balance between supply and demand from the 1930s through the early 1970s. Had prices evolved over some alternative path or had the Commission controlled production using some other criterion, Hubbert's prediction probably would have been less accurate.

The element of luck has been overlooked by those who use Hubbert's method to forecast the peak in global oil production. Their forecasts have consistently erred, suggesting an imminent peak, only to be revised when production continued to rise after the predicted date. Hubbert's methodology cannot predict the peak in global oil production because it mistakes the price-induced slowing of oil consumption during the 1970s and 1980s for the effects of resource depletion.

The genius in Hubbert's approach stems from a simple aspect of his bell-shaped curve: relatively large uncertainties about recoverable oil supply have relatively little effect on the timing of the peak. For example, updating Hubbert's analysis through 2003 and including Alaskan production indicates that about 230 billion barrels will be produced from fields in the United States, which is nearly 30 percent more than Hubbert's original estimate of 171 billion barrels. Despite this increase, the timing of the peak "backcast" hardly changes. Put simply, compared to pessimistic assessments, optimistic estimates for the amount of oil that remains only postpone the peak slightly. Given this fact, I can confidently state that the peak in global oil production will occur in my lifetime (I am 48).

The peak in global oil production marks a fundamental change in supply. Prior to the peak, production can increase

Hubbert's Model of Oil Production, Actual Oil Production and Price, and Oil Wells Drilled, Contiguous United States, 1900–2004



significantly with little or no increase in price (see figure). This is possible because most of the world's supply is found in a few very large fields. For example, there are more than 14,000 oil fields in the United States. Of these, the largest 100 contain nearly 40 percent of total supply. Increasing production from these large fields is relatively inexpensive. But once these large fields are depleted, they are replaced with fields that are one-tenth or one-hundredth their size. These high-cost fields reduce the profitability of production even at higher prices.

The importance of production costs is illustrated by the history of U.S. production. Oil production in the lower 48 states increased more than ten-fold between 1900 and 1970, but the real price of oil barely increased. After 1970, real oil prices doubled and then tripled. This price increase caused drilling to double. Nonetheless, production declined nearly 20 percent. As a result, the oil and gas sector increased its fraction of national investment without increasing its contribution to GDP—in effect, hundreds of billions of dollars were flushed down a dry hole.

The economic effects of the peak go beyond spending more at the pump. Because oil readily comes from the ground and is easily refined, it generates a large "energy surplus," which is the difference between the energy obtained and the energy used to obtain it. The large energy surplus powers the non-energy sectors of the economy, such that goods can be imported and exported at little extra cost, people can live far from work, and a small fraction of the workforce can feed those that produce the goods and services we associate with modernity. All of this may change following the global peak in oil production. After the peak, each barrel of oil will require more energy to extract, leaving less to power the non-energy sectors of the economy.

No alternative fuel now being researched generates a greater surplus or can be used more efficiently than oil. This reduction in the energy surplus differentiates the peak in global oil production from previous energy transitions. As society changed from wood to coal and from coal to oil, each new energy resource was "better" than its predecessor. It could be used more efficiently and it generated a greater surplus.

This creates an additional difficulty for the inevitable transition away from oil. Alternative fuels can generate an energy surplus large enough to power the U.S. and world economies, but to do so the infrastructure for the alternative fuel needs to be larger than the current oil infrastructure. If 1 Btu (British thermal unit) of oil could be used to extract 50 Btu of new oil from the ground (which was the ratio at the U.S. peak), most alternatives currently produce 2–10 Btu per Btu invested. The infrastructure for such alternatives would need to be five to twenty-five times larger than the current oil infrastructure.

The expanded infrastructure requires a timely transition. If the infrastructure for the alternative energy source is put in place before the peak arrives, the energy used to do so will have a relatively small impact on non-energy sectors. Conversely, if society waits until the peak, constructing the large infrastructure for the alternative fuel will siphon large amounts of energy from the non-energy sectors of the economy at the very time that the total supply and energy surplus from oil is shrinking. In short, society has to pay the costs for the transition. We can pay them now, while we have oil in the bank, or we can pay them later, when our oil bank account is emptying.

Economists often assure us that the competitive market will induce the needed investments in a timely fashion. I am less sanguine. The markets' ability to anticipate the timing of the peak and the rate of decline is limited by a lack of transparency in the world oil market. Estimates from the Organization of the Petroleum Exporting Countries (OPEC) of its proven reserves are a mix of geology and politics. This uncertainty is critical because much of the oil produced between now and the peak (and beyond) will come from OPEC. As such, the market cannot know how much oil remains and therefore cannot cause prices to rise in anticipation of the peak.

Charlie Mitchell/Shutterpoint.com

BP refinery in Scotland

The market therefore needs help to ensure that the entrepreneurial spirit will manage the transition from oil. But not the kind embodied in the Energy Policy Act of 2005. No serious person can believe that it will help. The current bill demonstrates that Republicans and Democrats have the same view of energy policy: they just give tax money to different groups. Sound policy should instead establish an economic environment that increases the economic returns and reduces the risk to long-term research and development on alternative energies. Policy should impose a large Btu or carbon tax on energy that is phased in over a long period, perhaps 20 years. This would signal entrepreneurs that there will be a market for alternative energies. Furthermore, increases in the energy tax should be offset by reducing other taxes, such as payroll or corporate taxes. Economic studies show that such

an approach can generate a win-win solution—reduce energy use (and the environmental damages not paid by users), stimulate research and development on alternative energies, and speed economic growth. Notice that the tax does not pick technologies—that will be left to the market, which is smarter than any politician (or economist!)

Government policy aimed at the next energy transition must strive for economic efficiency, but efficiency cannot be the sole criterion. The potential for large impacts may force policy makers to rely heavily on the precautionary principle (see p. 30), which compares the costs of being correct against those of being incorrect. We know that oil production will peak within our lifetime, we are pretty sure that market prices will not anticipate this peak, and we know that not having alternatives in place at the time of the peak will have tremendous economic and social consequences. So if society does too much now to stimulate alternative energies, as opposed to later, there will be some loss of economic efficiency. But if society does too little now, as opposed to later, the effects could be disastrous. Under these conditions, doing too little now in the name of economic efficiency will appear in hindsight as rearranging deck chairs on the Titanic.

Robert K. Kaufmann *is a Professor in the Center for Energy & Environmental Studies at Boston University, the author of three books and more than 50 peer-reviewed papers, and a consultant to the Japan National Oil Corporation, the European Central Bank, and the U.S. government.*