Special Report:

On the Precipice:
Energy Security and Economic Stability on the Edge

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Preface

When looking at this report for the first time, one may legitimately ask why an Army officer is writing about energy issues. The genesis for this project began many months ago when I was conducting research for a project related to the development of the future force in the US Army. I believed it was important to include an effective assessment of what the world might look like in the year the force was projected to complete its initial fielding (2030). So I set out to discover what some of the best minds in the world had to say about what the world might look like 20-plus years from now. Specifically, I intended to examine population growth, food production, water availability, and energy supplies. What I discovered shocked me.

Just under the radar of general public visibility a campaign has been waged for the past five or six years by geologists, scientists, economists, and former oil company executives to educate and inform all who would listen concerning serious supply issues related to the world's primary energy source: crude oil. Like most people, I had never heard of the term "peak oil" before 2003, and had not given any thought to the possibility of what might happen if the supply of oil were to plateau and subsequently decline. After reading literally hundreds of sources on the subject and interviewing some of the key figures in the field, my eyes were indeed opened.

Amply supplied with significant amounts of research material, I felt an obligation to put pen to paper and write a report on the subject. The American public must first be made aware of the scale of this encroaching problem; it will then become apparent that significant Government action is required.

The ultimate objective of this report is to encourage the United States Government to immediately initiate a series of detailed studies to ascertain the true nature of the threat posed by the peaking of world oil production, and to begin now building the foundation for action that will be necessary the inevitable day the peak occurs. As pointed out by several leading authorities, the lead time for meaningful mitigating action is measured in decades. It is critical, therefore, that action begin now.

Finally – but critically – I wish to express my sincerest thanks Dr. Colin Campbell who took significant time on many occasions to explain a number of issues to me, and to ASPO-USA co-founder Steve Andrews for publishing this study as a Special Report. Without Dr. Campbell's help and Mr. Andrew's willingness to publish an obscure Army officer's work, this report would never have seen the light of day.

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Introduction

Since September 11th 2001 the attention of America's polity has understandably been focused on battling terrorism and its underlying causes. Beginning in October 2001 and March 2003 it has likewise been almost totally consumed with the wars in Afghanistan and Iraq. These are legitimately serious issues that demand the focus and the best efforts of our Government. However, lurking beneath the surface of public discourse is an issue with the potential to dwarf all others because of its potential to cause severe damage to every aspect of life in the United States: the global peaking of crude oil production and ongoing depletion of reserves.

The debate among the world's leading scientists, geologists, and economists centers on when not if peaking will occur. Given the extraordinary degree to which the global economy – and the United States in particular – is linked to both the use of fossil fuels and its cheap price, the ramifications for the occurrence of a peak is staggering. Virtually every major component of the global economy is fueled by petroleum; demand is growing now even faster than the most optimistic estimates predicted.[1] If the supply of crude oil were to unexpectedly plateau and then begin an irreversible decline, the shock would be devastating, particularly to advanced economies like the United States.

A growing body of evidence presently exists that suggests the plateau may already have been reached. In fact, the global production of oil is likely to decline at precisely the same moment demand reaches an all-time high. If the United States Government does not take immediate action to mitigate this threat, and time reveals that indeed we have reached the peak, the negative consequences to follow would be worse than anyone dare imagine.

In America today, prophets of gloom and doom are a stable of the nightly news. It seems so many stories begin with "Shocking video at 11!" "Stunning new developments," or "Catastrophe in the making!" and yet life goes on the next day just as before, and no cataclysmic changes are observed. This engenders an attitude in the public that all warnings of impending peril are to be considered as so much hyperbole or simply as entertainment – it's no surprise that such headlines most often surface during ratings sweeps. What is different about this issue, however, is the number of facts which undergird the argument and the clear logic that flows from one event to the other. What makes it so difficult to believe, however, are the conclusions that result from that flow: the facts do not square with all we "know" about the foundations upon which our life is built and on our unquestioned certainty that in the future, things will always only improve.

What I will do in the remainder of this work is to lay out an understanding of what peak oil is, what two competing camps of experts have to say about it, how oil is inextricably linked to the economy, how a decrease in supply of crude would cripple the economy, discuss the viability of alternative sources of energy, make recommendations on actions that America must take immediately – and present a compelling, fact-based case which suggests the onset of the depletion of oil may be occurring now and why urgent action is required.

Peak Oil Defined

Some opponents of the peak oil occurrence have incorrectly identified "Peak Oil" as being synonymous with "out of oil," meaning that when the peak occurs, we'll suddenly find all the pumps at the gas station are empty. Rather, reaching the peak means that we'll have pumped roughly half the global endowment of crude oil from the ground, and once that happens, the remainder becomes increasingly difficult to extract and every year thereafter less and less is produced. This annual decrease in production will continue until some time many decades hence it becomes so difficult to pump that it becomes practically infeasible to do so, and the age of oil will have come to an end.

When a new oil field is discovered and pumping begins, the reservoir is obviously full, and the pressure created by the mass of the oil facilitates its removal. As time passes and the volume decreases, there is considerably less pressure and the oil flows more slowly. Over the years as technology has advanced, the amount of oil that can be extracted from each field has increased. But once a field has reached its peak and entered decline, the descent is terminal and no amount of technology has been able to stop it. The lower-48 United States is perhaps the best illustration.

The first major discovery of oil in the United States was in Pennsylvania in 1859. Texas made its entrance with the discovery of the famous "Spindletop" in 1901 and by the mid 1940s the United States had established itself as the largest oil producing nation on earth. But in 1970, oil production hit its peak in the US at nearly 3.5 billion barrels per year. Despite the presence of more oil wells per square mile than any region on earth[2] and the application of the most modern technology available, American production began to decline after this peak and nothing has been able to check the slide. In 2005 the lower-48 produced only 1.9 billion barrels. But it's not just the US that is suffering a drop in production: according to Congressman Roscoe Bartlett (R, MD), 35 of the world's 48 major oil producers have hit their peak and are in irreversible decline.[3]

What of new finds? While the aforementioned 35 producers may be on the downside of the depletion curve, improved technological capabilities and an increase in knowledge of geology increase our chances of finding new oil fields. But will the increase from new finds be enough to offset the declining production and continue to fuel the rising hunger of a developing global economy? There are generally two schools of thought on this question and their conclusions couldn't be more different.

Peak or Undulating Plateau

One camp believes that a detailed analysis of all available evidence indicates that a peak in the global production of crude oil will take place sometime between now and the 2020 timeframe, and the other believes that while a peak may occur, the result will be more an 'undulating plateau' than a precipitous drop to zero, and even that won't occur before 2040.

On the peak oil side are a number of geologists, former oil company executives and economists who believe that the maximum global production will be reached in the near term. They have been led for many years by petroleum geologist Dr. Colin J. Campbell who previously worked for Texaco, Amoco, and British Petroleum. He currently heads the Association for the Study of Peak Oil and Gas (ASPO) and is a trustee of the London-based Oil Depletion Analysis Center.

In order to understand why there will be a peak, Dr. Campbell explained that, "oil was formed in the geological past under now well understood processes," and further that oil is "a finite resource subject to depletion and that in turn means that there is an Oil Age."[4] He bases his estimation of the timing of the peak on the following four questions: 1) How much oil has been pumped out since the oil age began; 2) how much oil remains in known fields; 3) how much will be produced from fields yet to be found; and 4) what is the total oil endowment (the sum of numbers 1-3 above)?[5]

He posits that if one measures the total amount of oil produced thus far with the amount of known oil still in the ground and adds an estimation of what is yet to be discovered, the result will be the total endowment of oil that exists; by subtracting the amount already pumped from that in the ground, we can determine the mid point, and from that knowledge estimate when the peak will occur.

Virtually all competent authorities, regardless of which side of the peak oil argument they stand, agree that approximately one trillion barrels of oil have thus far been pumped from the ground. There is a great deal of dispute, however, on the remaining questions. Dr. Campbell believes the ultimately recoverable reserves (URR) reported by various oil companies and countries is grossly inflated because, as he wrote in July 2002, "the implications of the decline of the world's premier energy source are so pervasive that in political terms it is easier 'not to know.'"[6] This view is not without merit. The seven years inclusive from 1996 to 2002, Saudi Arabia produced an average of 3.4 billion barrels of oil per year. In the year 1996, Saudi Arabia reported it had known reserves of 259.0 billion barrels. After seven years of pumping an average of 3.4 billion barrels of oil a year, a total of approximately 23.5 billion barrels, the Saudis reported their reserves were now slightly *higher*, at 259.3 billion barrels.[7]

In fact, between 1996 and 2002 Iran, Iraq, Kuwait and Saudi Arabia reported the identical or higher reserves every year – despite the fact that well over 43 billion barrels of oil had been produced. But perhaps more striking is the fact that in 1987, Abu Dhabi, Dubai, Iran and Iraq together reported reserves of 128.3 billion barrels. The next year each increased its reported total to be more than double the previous year, for a 1988 total of 289.1; Saudi Arabia followed them two years later increasing their reported reserves from 170.0 in 1989 to 257.5 in 1990.[8] In no case had any of the increases come as a result of new discoveries.

What must also be taken into consideration is that no external auditing capability exists nor is there any universally accepted definition of the term "proven reserves." Each country is therefore free to publish whatever statistics they wish and to apply whatever definitions they see fit. The obvious result is that there is no effective way to ensure reported national reserves are accurate. The pressures to inflate the numbers, as opposed to underreporting them, are significant: the larger the stated reserves, the larger the political clout a nation enjoys. Further, the smaller the reserves of a particular field or nation, the less likely it is that outside agencies will invest in future production.

The next category Dr. Campbell cites is the yet-to-find group. Based on an examination of discovery trends for the past half century it is beyond question that we are finding less and less every year. Global oil discovery peaked in 1962 when approximately 50 billion barrels (Gb) of oil was found. According to Dr. Roger D. Blanchard, author of "The Future of Global Oil Production," "For the January-June period of 2006, only ~3.6 Gb of oil was discovered. That follows the discovery of ~5 Gb in 2005 and ~7 Gb in 2004.[9]

Since present global consumption of oil is approximately 30 Gb per year, it is obvious that we're consuming vastly more oil than is being discovered, and it won't take too many years of that imbalance to reach the peak of supply. As with the amount of oil already produced, there is little dispute on the amount of oil that is found each year. What constitutes Dr. Campbell's fourth question, the total endowment, generates a great deal of disagreement.

Dr. Campbell estimates that an approximate date for the peak of oil to occur is 2010, but even he admits this dates is not certain. The reason, he says, is because of the previously cited dubious accuracy of the publicly reported reserves. What is less subject to obfuscation, however, is the performance of known fields. The amount of oil produced from any particular field can be measured relatively accurately and charted over time. According to British Petroleum's "BP Statistical Review of World Energy June 2007" 29 of the 54 oil producing nations (or groupings of small nations) on which they report showed a decline in production from the year before.[10] If the actual performance of known fields is extrapolated to other existing fields, a reasonable estimate can be made of reserves.

The May 2006 *Reason Magazine* reported a consensus on the amount of global reserves by some of the world's most respected institutions as being, "1.1 trillion barrels by the industry journal *World Oil*, 1.2 trillion by the oil company BP, and 1.3 trillion by the *Oil and Gas Journal*."[11] Dr. Campbell believes the number is slightly less than the above, which he believes are inflated for political and economic reasons; in 2006 he published a figure of .93 trillion barrels. Adding up all the four categories of figures, Dr. Campbell arrives at a possible peak date of 2010.[12] There are others, however, who strenuously dispute this assessment.

Leading those who argue against a near-term peak in oil is Dr. Daniel Yergin, Chairman of Cambridge Energy Research Associates (CERA). There are others in this camp – such as Shell Oil Company, ExxonMobil, and others – but they essentially share the same position. For simplicity, I will examine the position of CERA as representative of those disputing an impending peak oil occurrence.

CERA believes the peak in oil production will likely not happen until 2040 at the earliest because, though they agree that almost 1.1 trillion barrels of oil have been produced, CERA disagrees with Dr. Campbell in that instead of approximately one trillion barrels of global reserves remaining, there are more than 3.8 trillion. Further, when the global oil peak does occur there will not be a sharp and irreversible decline in production, but rather an "undulating plateau." CERA defined this plateau in a November 2006 press release by writing, "(The undulating plateau) will be asymmetrical – with the slope of decline more gradual and not mirroring the rapid rate of increase – and strongly skewed past the geometric peak. It will be an undulating plateau that may well last for decades (to view CERA's position, see their press release by clicking here)."[13]

One of the reasons CERA believes there will not be a sharp drop off in production once the peak occurs is that in the future, the growing gap between demand and crude supply will be offset with, "Non-traditional or unconventional liquid fuels such as production from heavy oil sands, gas-related liquids (condensate and natural gas liquids), gas-to-liquids (GTL), and coal-to-liquids."[14] Current policy-makers ought not be concerned by the alarms raised by the adherents to a peak oil occurrence because, "It is likely that the situation will unfold in slow motion and that there are a number of decades to prepare for the start of the undulating plateau. This means that there is time to consider the best way to develop viable energy alternatives that would eventually provide the bulk of our transport energy needs and ensure that there is a useable production stream of conventional crude for some time to come."[15]

Additionally CERA disputes one of the fundamental assumptions upon which peak oil theory is built: proven reserves. "Those who believe a peak is imminent tend to consider only proven remaining reserves of conventional oil," they contend, "which they currently estimate at about 1.2 trillion barrels. In the view of many petroleum geologists, this is a pessimistic estimate because it excludes the enormous contribution likely from probable and possible resources, those yet to be found, and plays down the importance of unconventional reserves in the Canadian oil sands, the Orinoco tar belt, oil shale and gas-to-liquids projects. CERA believes the global inventory is some 4.8 trillion barrels, of which about 1.08 trillion barrels have been produced, leaving 3.72 trillion conventional and unconventional barrels, an order of magnitude that will allow productive capacity to continue to expand well into this century."[16] This statement, if correct, would render any near-term concern over global oil supplies moot. When the details under the claims are analyzed, however, the concern returns.

Four of the more central tenets upon which CERA's position is built concern their estimate of proven remaining reserves of 3.8 trillion barrels vice the 1.1 trillion estimated by the peak oil adherents. CERA explains their estimates by quantifying: 1.) the amount of oil that can be retrieved with advanced technology, 2.) the amount of oil that is yet to be discovered, 3.) the amount of heavy oil and 4.) oil shale that could be produced. An analysis of these four tenets weakens the CERA position, particularly when examined against facts provided by Government-sponsored reports on the ramifications of utilizing these very alternatives.

Risks and Realities

When reading CERA's estimates regarding the availability of these four categories, one is tempted to think it will simply be a matter of economics and choice: once the supply of crude drops to a certain point and it becomes economical to begin increasing the production of Canada's tar sands and America's huge stocks of shale oil, industry will ramp up in those areas and demand will continue to be met. It sounds very much like standing at a gas station in front of a common three-hosed pump: the one on the right is regular unleaded (the cheapest), the middle one is mid-grade (a bit more expensive), and the third is super unleaded (the most expensive) – once regular runs out, you just pick up the next nozzle and keep filling your car.

Yeah, it will cost you more, but you won't have any problem filling your tank. Such an understanding grossly understates the magnitude of the problem.

In February 2005 Dr. Robert L. Hirsch, senior energy program advisor for Science Applications International Corporation (SAIC), published the first of three reports he wrote commissioned by the Department of Energy called, *Peaking of World Oil Production: Impacts, Mitigation, and Risk Management* (along with his October 2005 and February 2007 reports, these are herein referred to as "The Hirsh Reports"). This work, one of the most comprehensive and balanced works to date on the subject of peak oil, includes a critical component that had been missing from other analysis of the issue. Having particular relevance to CERA's contention that multiple crude alternatives would make up the difference for lost production, Dr. Hirsch discusses what it would take to actually produce the necessary quantities. His description of the difficulties and consequences inherent in that process put CERA's projection in a different light. First we'll look at the four primary non-conventional components CERA used to build their case for 3.8 trillion barrels of reserve, and then we'll specifically look at the possibilities, consequences and ramifications of each.

The four categories are: 1) 758 billion barrels (Gb) of future discovery; 2) 592 Gb of enhanced oil recovery techniques; 3) 704 Gb of oil shale; and 444 Gb of heavy oil (tar sands).[17] To provide context for what follows, a few facts must first be presented. Presently, the world produces about 85 million barrels a day (mbd) of crude oil and other energy liquids. Virtually every competent authority is in agreement that by 2030 unconstrained global demand would be 50% higher than it is today. Using figures provided by ExxonMobil, the world would have to be pumping 115mbd in 2030.[18]

Consequently, in 23 years hence the world will have to discover not only 30mbd above the 85mbd in current production to reach the 115mbd – because as previously stated, more than 60% of existing fields are in decline – but we'll also have to make up for 23 years of decline *in addition to* the 30mbd required increase. Using very conservative calculations that decline would equal approximately 6mbd.[19] That 36mbd increase represents a requirement of more than 42% above today's figures. Where will this oil come from? According to CERA, the four categories previously listed will provide it.

To examine the viability of this contention we will first consider the capability of each of these four categories, beginning with the 758 Gb of undiscovered oil. To put in perspective how much oil that is, we must consider the discovery trends of the past few decades. One would expect that, particularly over the past two decades when significant increases in technological capability has come online in the oil industry, discovery would show a marked increase. But that is not what we see. Instead what we find is an unmitigated decline.

Covering the 30 years 1976-2005, the total oil discovered was 499 Gb.[20] That's an average of 16.6 Gb a year. But the discovery per year over those three decades hasn't been uniform. The past 20 years the average was 11.8 and the final 10 years, 9.5 Gb; in 2004-5 the total combined was only 12 Gb.[21] The trend over the next 23 years is certain to remain at or below the past 10 years. Even assuming an unrealistic plateau in discovery rate at the 9.5 Gb per year, it would take almost 80 years to discover 758 Gb. But if a more realistic estimation of the rate of future discovery turns out to be more like the numbers found in 2004 and 2005 (5 and 7GB respectively), it would take until well after the turn of the next century. Or put another way, we are consuming approximately 30 Gb per year and discovering only 5-7 Gb. New discovery is clearly not likely to produce meaningful amounts above current yields. But perhaps the Canadian Tar Sands or the United States' oil shale offer promising inputs.

Oil from Unconventional Sources

According to Hirsch's February 2005 report, Canada and Venezuela together are estimated to have between 3 and 4 trillion barrels of total resources, about 600 billion barrels of which are thought to be economically convertible – considerable by any standard.[22] However, Hirsch writes, "This relatively low fraction is in large part due to the extremely difficult task of extracting these oils."[23] The difficulty is measured not simply in dollars per barrel, but in ecological and geological terms. In order to demonstrate the difficulty inherent in producing meaningful amounts of crude oil to the global total, we will discuss the similarities between converting both Canadian and Venezuelan tar sands and America's massive oil shale deposits into oil.

Under an area of the Midwest United States that includes parts of three states (Colorado, Utah, Wyoming) sits what some experts believe are trillions of barrels of recoverable oil – presently locked away in shale. In a speech presented at the Heritage Foundation in Washington, DC in March 2007, MIT's Dr. Daniel Fine said, "We're talking still about 1.2 trillion, 1.3 trillion barrels of oil; the Rocky Mountain region is the Saudi Arabia of oil shale."[24] That would be enough fossil fuel to power all of America's needs for more than two centuries. The question, however, is the feasibility of getting it from its natural state in the ground and transforming it into a usable material. The Hirsch Reports and a 2005 RAND study called "Oil Shale Development in the United States: Prospects and Policy Issues" both come to the same conclusion on issues relating to the development of America's oil shale: while it is technologically possible to produce usable petroleum products from shale oil, considerable difficulties must first be overcome.

Because no company or organization has to date invested the money to create the infrastructure necessary to convert the rock into oil, it would take decades before a meaningful amount of oil could be extracted. To quote the RAND study:

> **Development Timeline.** Currently, no organization with the management, technical, and financial wherewithal to develop oil shale resources has announced its intent to build commercial-scale production facilities. A firm decision to commit funds to such a venture is at least six years away because that is the minimum length of time for scale-up and process confirmation work needed to obtain the technical and environmental data required for the design and permitting of a first-of-a-kind commercial operation. At least an additional six to eight years will be required to permit, design, construct, shake down, and confirm performance of that initial commercial operation. Consequently, at least 12 and possibly more years will elapse before oil shale development will reach the production growth phase. Under high growth assumptions, an oil shale production level of 1 million barrels per day is probably more than 20 years in the future, and 3 million barrels per day is probably more than 30 years into the future.[25]

But perhaps more important than the physical ability to produce oil from shale, is the damage it might do to the environment. The scale of the problem to the water supply (three to five barrels of water are needed each barrel of oil produced from mining or surface retorting) is enormous: to produce 3mbd of oil would require upwards of 10 million barrels of water necessary *per day*.[26] Just as problematic, is the staggering volume of waste product created.

Again RAND: "Roughly 1.2 to 1.5 tons of spent shale result from each barrel of oil produced by surface retorting."[27] Meaning, if we use the 3mbd figure cited as a goal by various reports, that would necessitate the aforementioned nine or more million barrels of water per day and create (using the low number) 3.6 million tons of waste product – *per day*. Unless solutions to the waste product can be found, that three-state region of the United States – among the most beautiful in America – would be turned into a waste land.

The tar sands found in Alberta and the Orinoco belt of Venezuela are the 'heavy oils' referred to in the CERA study. Canada has already invested billions of dollars in the development of those fields, and after decades of operation are producing a little over 1mbd. For many reasons, it would be very difficult to increase that rate of production.

Already there are protests in Alberta because the conversion process has created a large contaminated pond of water. From Canada's *The Globe and Mail* newspaper, Jeffrey Simpson reported on July 5, 2006: "A cubic metre of oil, mined from the tar sands, needs two to 4.5 cubic metres of water. Approved oil sands mining operations -- not the in situ kind that extract oil from tar sands far below the surface -- will take twice the annual water needs of the City of Calgary."[28] Canada would have to triple their output to have even a marginal impact on rising global demand. Where they would get triple the amount of natural gas necessary to produce this increase, and how they would manage the tripling of water requirements and the associated contamination is not clear.

Next we will discuss the projected increase in available oil through means of increased oil recovery techniques and new technology.

Technology and Enhanced Oil Recovery

CERA calculates Enhanced Oil Recovery techniques will provide an astounding 592 additional billion barrels of oil.[29] But to provide context for CERA's claim, we again turn to the February 2005 Hirsch report: "Improved Oil Recovery (IOR) is used to varying degrees on all oil reservoirs. IOR encompasses a variety of methods to increase oil production and to expand the volume of recoverable oil from reservoirs. Options include in-fill drilling, hydraulic fracturing, horizontal drilling, advanced reservoir characterization, enhanced oil recovery (EOR), and a myriad of other methods that can increase the flow and recovery of liquid hydrocarbons."[30] Himself a former oil company executive, Dr. Campbell explains that part of the reported successes gained through enhanced oil recovery techniques has actually been a mirage.

"Most reported 'enhanced recovery' is in fact an illusion," the 40 year veteran of the oil industry said.[31] He explained that following the imposition of Congressionally mandated reporting regulations in the early years of the industry, oil companies "rightly reported very conservatively on a step by step basis as the various phases of development were completed, and then revised their reserves upwards, giving a comforting but misleading image of steady growth. It was easier to explain this as the result of enhanced recovery or technology." Dr. Campbell does not discount the significance of oilfield advancements, and credits technology for permitting more oil to be recovered than would otherwise have been the case. What he argues against, however, is an unsubstantiated overestimation of what technology can do.

It is important to note that technology and enhanced recovery techniques are not new, and have been applied to oil fields for decades. For example, when oil was discovered in the US in the early 20th Century, legitimate reserve figures were based on the amount of oil that could be removed with then-existing technology. As developments were made more of the oil could be removed, thus increasing the reserves reported. But as new fields were discovered, these techniques were applied from the beginning and as a result, it became possible to make a more accurate initial estimate of the amount of oil that could be produced. The result is that as time passes and technology advances, there becomes less room for "reserve growth" because we have a much better understanding of what's recoverable at the time of discovery. It is also crucial to note that technology does not enable a field to produce more than was ever in it, only to maximize our ability to remove more of the original endowment.

According to a report commissioned by the University of Salzburg, enhance oil recovery (EOR) measures have not had the impact commonly believed. The report stated:

> EOR measures have already been applied for more than twenty years, and these measures are accounted for in production forecasts… To illustrate (why EOR is only partially effective), the influence of EOR measures at one of the largest US fields is investigated in figure 5. The Yates field, which was found in 1926 in Texas, has produced since 1929. Since peak production in 1970 the production rate has declined by more than 75 percent. In 1993 hot steam and chemicals were injected to enhance the production rate. This measure was successful for about 4 years. Afterwards the decline was even steeper, exceeding 25 percent per year instead of 8.4 % as before. Today the production rate is even below the level it would be without these measures.[32]

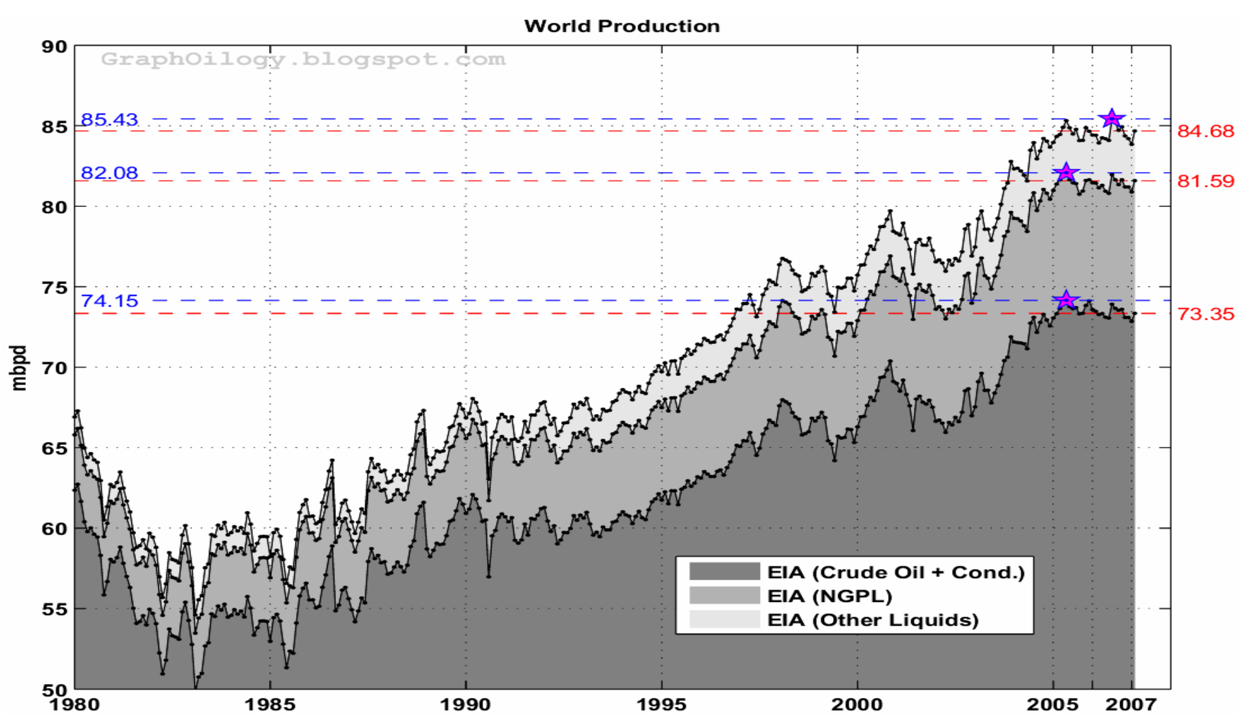
In a July 31st 2005 Washington Post commentary, CERA Chairman Dr. Daniel Yergin sought to calm any fears the public might have regarding the peaking of oil by explaining how technology would provide solutions to the supply problem:

> There will be a large, unprecedented buildup of oil supply in the next few years. Between 2004 and 2010, capacity to produce oil (not actual production) could grow by 16 million barrels a day -- from 85 million barrels per day to 101 million barrels a day -- a 20 percent increase… The share of "unconventional oil" -- Canadian oil sands, ultra-deep-water developments, "natural gas liquids" -- will rise from 10 percent of total capacity in 1990 to 30 percent by 2010. The "unconventional" will cease being frontier and will instead become "conventional"… But at least for the next several years, the growing production capacity will take the air out of the fear of imminent shortage. And that in turn will provide us the breathing space to address the investment needs and the full panoply of technologies and approaches -- from development to conservation -- that will be required to fuel a growing world economy, ensure energy security and meet the needs of what is becoming the global middle class.[33]

To test the validity of Dr. Yergin's reassuring words, let us examine the status now two years later of the programs he cited as reasons for optimism. One would expect to find that Canadian oil sands and natural gas liquids had increased production to something close to the 30% he predicted for 2010, and we would see an increase in production capacity near the 20% he likewise expected to see by 2010. An examination of the data over the past two years, however, reveals his optimism was misplaced. First let us look at the "unconventional" inputs.

One of the most widely accepted standards for production statistics is BP's annual "Statistical Review of World Energy," which lists many useful oil-related global statistic one could imagine. One of these statistical categories is global refining capacity. If what Dr. Yergin said in 2005 regarding a 20% increase in refining capacity was correct, then we would expect to find an approximate one sixth of that increase between 2004 and 2006. In BP's 2007 review of World Energy (with data through 2006), we find total reported global refining capacity to be 87.238mbd.[34] The BP report for 2005 (with data as of 2004) listed refining capacity to be 84.592[35] – showing a 3.1% increase over two years. For Dr. Yergin's projection to be on track, an increase of 6.7% should have occurred.

Dr. Yergin also predicted that unconventional oil would make up to 30% of the total production by 2010. In 2005 the Department of Energy's Energy Information Agency (EIA) reported that the percentage of unconventional oil was approximately 13.0% of total daily oil production;[36] in 2006 the daily average was 13.2%[37] - virtually unchanged. The actual data hardly supports Dr. Yerign's claim of "a large, unprecedented buildup of oil supply." Rather, the Wall Street Journal reported on June 22nd 2007 that, "World oil demand is rising twice as fast as a year ago, straining the petroleum industry's ability to keep up with global needs and likely resulting in higher and more-volatile prices for some time to come."[38] Had Dr. Yergin's "unprecedented" supply developed as suggested, there would be no strain on the system. But as can be seen from the EIA graph below, two years after Dr. Yergin's optimistic appraisal, unconventional production has been flat, as has global petroleum of all sources.



Unfortunately, it is not simply the supply of crude that is in short supply. Even the Canadian oil sands have not had the increase in production expected.

Though there continues to be significant investment in the Canadian fields, there are equally significant obstacles to further development. A May 2007 study conducted by the University of Alberta complained that although there are significant amounts of oil in Canada's sand fields, environment constraints could actually render future production increase impossible:

> But to produce one million barrels of oil a day, industry requires withdrawals of enough water from the Athabasca River to sustain a city of two million people every year. During the past year a variety of industry and government agencies have recognized that the intensive water requirements of unconventional oil, combined with climate change, may threaten the water security of two northern territories, 300,000 aboriginal people and Canada's largest watershed: the Mackenzie River Basin. The Petroleum Technology Alliance Canada, for example, recently stated that its "largest concern" in the oil sands was water use and reuse because "bitumen production can be much more fresh water intensive than other oil production operations." A 2006 Alberta report (Investing In Our Future) noted that "over the long term the Athabasca River may not have sufficient flows to meet the needs of all the planned mining operations and maintain adequate stream flows.[39]

Generally speaking there is great benefit to being optimistic. But when that optimism disregards second and third order effects, it becomes dangerous. When organizations and companies like ExxonMobil, Shell, CERA, and others confidently assert that in the coming years when cheap crude oil begins to decline "non-conventional" oil will simply pick up the slack – without explaining how or who will produce the shortfall – they engage in a dangerous game that could have serious repercussions for the global economy.

On February 8th of this year the President of the Shell Oil Company, John D. Hofmeister, gave a speech in Pittsburg, PA on the subject of future energy security. As reported in the Energy Bulletin, journalist Byron King asked Mr. Hofmeister his thoughts on peak oil. According to Mr. King, Mr. Hofmeister responded, "Among informed Shell executives, there is a rejection of the Peak Oil theory."[40] Mr. Hofmeister based his contention on three points:

1. Peak Oil deals with conventional oil and does not take into account sources of unconventional oil, such as tar sand, oil shale, and heavy oil.
2. Peak Oil assumes that technology is static, when, in reality, there have been "huge strides" in the ability to enhance oil recovery from older oil fields.
3. By diversifying energy resources, "People will switch demand to other energy sources" long before conventional oil runs out.[41]

But as has been shown above with the Canadian oil sands and previously with the American oil shale, the obstacles to effective production of these two means of supply are enormous, and will require billions of dollars more investment and decades of development even to produce a marginal amount of usable oil – *if* the significant environmental and ecological constraints can be managed effectively. Failing to acknowledge the significant difficulties inherent in producing meaningful amounts of oil from non-conventional sources – and all the while doing nothing to prepare for a peak in conventional crude oil followed by a terminal decline – we set the stage for extraordinary disruptions to both the national and global economies.

Biofuels

But what of other proposed solutions? Many feel the answer to a decrease in global oil production is to increase biofuel production, especially since it comes from a renewable source. Unfortunately, the foundation upon which biofuels rest – a large, sustainable crop yield – is itself contingent upon the inputs produced from fossil fuels. The same danger to our food supply posed by the reduction in available petroleum inputs (discussed on page 20) would likewise affect the amount of plant matter that could be produced to make fuel. If the amount of food begins to decline, it will be increasingly difficult to justify diverting a significant portion of crops to energy production.

Dr. David Pimentel of Cornell University and Dr. Tad Patzek of UC-Berkley wrote in the November 2006 edition of *BioScience* magazine that despite growing enthusiasm about the ability of biofuel to reduce our dependence on foreign imports of oil, even with a significant portion of crops devoted to energy production, the impact on our overall energy usage is small. They wrote, "Yet the 18 percent of the US corn crop that is now converted into 4.5 billion gallons of ethanol replaces only 1 percent of US petroleum consumption. If the entire corn crop were used, it would replace only 6 percent."[42] But of greater concern to Doctors Pimentel and Patzek, is the energy inefficiency of the process.

"Our up-to-date analysis of the 14 energy inputs that typically go into corn production and the 9 invested in fermentation and distillation operations," they wrote, "confirms that 29 percent more energy (derived from fossil fuels) is required to produce a gallon of corn ethanol than is contained in the ethanol. Ethanol from cellulosic biomass is worse: With current technology, 50 percent more energy is required to produce a gallon than the product can deliver."[43] Moreover, a recent United Nations study pointed out other costs to diverting cropland to fuel production. "The availability of adequate food supplies could be threatened by biofuel production to the extent that land, water, and other productive resources are diverted away from food production."[44]

It could be that with more research and the discovery of newer technologies these ratios could be improved. It is also possible that other agricultural products or processes can be found that would make efficient use of otherwise useless bio waste products; all such efforts should be strongly encouraged and financially supported. But it is clear that present technology and land-use constraints indicate that there are serious limitations to the degree that biofuels can offset a reduction in fossil fuel.

Addiction and Recognition

When President Bush said the country was "addicted to oil" in his 2006 State of the Union speech, the alliteration was much more literal than anyone could have imagined; the 'withdrawal symptoms' that would beset the United States if a peak of oil caught us unprepared would be as bad for society as would be suffered by a crack cocaine addict if his supply of drugs were suddenly reduced.

That's why it is so critical that we recognize the potential scale of the problem today and take action immediately. As pointed out by Dr. Hirsch, if we begin taking action before the onset of the peak, the damage done and the pain incurred will be mitigated; if we fail to act until production at the wellhead announces the decline has begun, the pain endured will be markedly worse, and the risk of global instability will increase to a dangerous level. Dr. Hirsch clarified the scope of the problem in remarkably clear but sober terms in his February 2005 report when he wrote:

> Mitigation will require an intense effort over decades. This inescapable conclusion is based on the time required to replace vast numbers of liquid fuel consuming vehicles and the time required to build a substantial number of substitute fuel production facilities. Our scenarios analysis shows:
>
> • Waiting until world oil production peaks before taking crash program action would leave the world with a significant liquid fuel deficit for more than two decades.
> • Initiating a mitigation crash program 10 years before world oil peaking helps considerably but still leaves a liquid fuels shortfall roughly a decade after the time that oil would have peaked.
> • Initiating a mitigation crash program 20 years before peaking appears to offer the possibility of avoiding a world liquid fuels shortfall for the forecast period.
>
> The obvious conclusion from this analysis is that with adequate, timely mitigation, the economic costs to the world can be minimized. If mitigation were to be too little, too late, world supply/demand balance will be achieved through massive demand destruction (shortages), which would translate to significant economic hardship. There will be no quick fixes. Even crash programs will require more than a decade to yield substantial relief.[45]

If we are hit with a peak flat-footed, having taken none of the mitigating measures recommended in the Hirsch Reports, the cost to the United States will be extraordinary by any measure.

The Logic for Action

No serious scientist, geologist or economist believes that the cheap crude oil upon which our society currently runs will last forever; all believe it will someday end. Since it is clear that an effective transition will be measured in decades, given that all agree the world has pumped approximately one trillion barrels of oil from the ground thus far, it is an imperative that we begin immediately to analyze, conceive, and then implement a plan to transition to alternatives before being forced to do so as a result of a supply in terminal decline.

As the Hirsch and RAND reports graphically demonstrate, the lead time necessary to create the infrastructure that would permit a transition to alternatives to crude are measured in decades;[46,47] every day we delay in embarking on meaningful program makes it more likely we'll face a convulsive, devastating shock to our way of life when the decline in production begins.

Impediments to Action

One of the problems inherent in the acceptance of the date of peak oil is the dispute involving the amount of oil still in the ground: the ultimately recoverable reserves (URR). The size of these reserves are the pivot of determining an accurate assessment. In a telephone interview, Dr. Campbell made a point to clarify an important fact concerning his projection of a 2010 peak: "There's only one thing I can tell you with certainty regarding my assessment: it's probably wrong! The question is, by how much."[48] He explained that because there exists no globally enforceable single standard for reporting individual reserves, each nation and/or oil company is free to choose their own definitions of what they report, and to report whatever numbers supports their economic or political purposes.

Consequently, any projection of global URR based on publicly announced figures must be understood to be an estimate that could be artificially higher or lower, depending on the circumstances. What does provide a fairly accurate assessment, however, is to analyze past performance of oil fields as a measure of future performance. "You see, if you can measure how a field has performed over time," Dr. Campbell explained, "and extrapolate that to some future date cutoff, say 2075, you can then subtract past production to arrive at a reasonable estimation of future production."[49] He correlates the publicly announced data with his analysis, combines it with confidential sources he receives from industry associates he's accumulated over his 40 year career in the petroleum industry, and makes his best assessment. So he concedes his estimate of the peak oil date cannot be precise because the data itself is not precise. It is therefore possible that his projections are just as likely to be too far into the future as too near.

Another impediment to action is the fact that many of these same experts have changed the date of their estimations over time to later dates, opening themselves to charges of incompetence. Possibly the most shrill critic of peak oil adherents is Michael C. Lynch, President of Strategic Energy & Economic Consulting, Inc. Mr. Lynch sees no evidence that a peak will ever occur, and is a frequent antagonist of Dr. Campbell in his published works. In one article he wrote, "The work of the Hubbert modelers (which he cites Campbell as being) has proven to be incorrect in theory, and based heavily on assumptions that the available evidence shows to be wrong. They have repeatedly misinterpreted political and economic effects as reflecting geological constraints, and misunderstood the causality underlying exploration, discovery and production."[50]

However, after analyzing a significant number of peak oil positions – both pro and con – Dr. Robert Hirsch concludes his February 2005 report by writing:

> **1. World Oil Peaking is Going to Happen**
> World production of conventional oil will reach a maximum and decline thereafter. That maximum is called the peak. A number of competent forecasters project peaking within a decade; others contend it will occur later. Prediction of the peaking is extremely difficult because of geological complexities, measurement problems, pricing variations, demand elasticity, and political influences. Peaking will happen, but the timing is uncertain.[51]

Compulsion for Action

What, then, ought American policy-makers do? If the Campbell-led group of geologists and scientists argue strenuously that the peak of oil production will occur and the Yergin and Lynch-led group argue just as strenuously that it either will not occur or won't come for decades, why should today's leaders act now? There are three points that strongly argue for immediate action: 1.) the preponderance of evidence, and 2.) the logic of cause-and-effect, and 3.) the consequences that would be paid by a world caught flat-footed at the peak.

As detailed earlier, those who argue against the occurrence of a peak in the near term do so upon the assumption that non-conventional sources of energy (coal-to-liquids, oil from tar and shale, etc), while more expensive, can be readily obtained on demand and that technology will find solutions when required. But as the RAND, Hirsh and a February 2007 Government Accountability Office (GAO) report conclusively state the lead-time necessary to produce meaningful amounts of oil from sand and shale are measured in decades, and as the GAO and RAND specifically state, no such program to begin this process for shale currently exists. [52,53] Moreover, oil sands are only producing in comparatively marginal amounts, and significant difficulties must be overcome before producing to the 3-5mbd level will be possible.

As a result, if the peak of oil were to happen before the decades of necessary investment and development mentioned above had taken place, there is no doubt the global economy in general and the United States in particular would suffer unprecedented damage.

> *February 2007 GAO report*:
>
> The consequences would be most dire if a peak occurred soon, without warning, and were followed by a sharp decline in oil production because alternative energy sources, particularly for transportation, are not yet available in large quantities. Such a peak would require sharp reductions in oil consumption, and the competition for increasingly scarce energy would drive up prices, possibly to unprecedented levels, causing severe economic damage. While these consequences would be felt globally, the United States, as the largest consumer of oil and one of the nations most heavily dependent on oil for transportation, may be especially vulnerable among the industrialized nations of the world.[54]
>
> *February 2005 Hirsch Report*:
>
> The problems associated with world oil production peaking will not be temporary, and past "energy crisis" experience will provide relatively little guidance. The challenge of oil peaking deserves immediate, serious attention, if risks are to be fully understood and mitigation begun on a timely basis… Peaking will result in dramatically higher oil prices, which will cause protracted economic hardship in the United States and the world. However, the problems are not insoluble. Timely, aggressive mitigation initiatives addressing both the supply and the demand sides of the issue will be required… Mitigation will require a minimum of a decade of intense, expensive effort, because the scale of liquid fuels mitigation is inherently extremely large.[55]

This statement cannot be overemphasized: if we know it is a fact that decades of investment and development would be required before meaningful amounts of usable petroleum products from non-conventional sources could be produced, and if the peak then caught us flat footed, it would be a certainty that the national and global economy would suffer extraordinary damage. A glimpse of just how much damage might be suffered was provided two years ago by no less an authority than now-Secretary of Defense Robert Gates.

On June 23, 2005, a group of high-ranking former officials gathered in Washington, DC to conduct a simulation in which they played the role of a Presidential cabinet advising on the potential security and economic consequences of an oil supply crisis. This event – called the "Oil ShockWave" – was a sophisticated scenario exercise developed by Securing America's Future Energy and the National Commission on Energy Policy to examine the implications of a global oil shortfall and to explore possible responses to and protections against, such a crisis.[55.1] Then-president of Texas A&M University, Robert Gates filled the role of National Security Advisor.

After playing out three disruption-related scenarios, the group arrived at two key conclusions. In the 2005 report summary Dr. Gates wrote:

> First, the economic and national security risks of our dependence on oil—and especially on foreign oil—have reached unprecedented levels. The threat is real and urgent, requiring immediate and sustained attention at the highest levels of government. Second, if we wait until a crisis occurs to act, the nation will have access to few, if any, effective short-term remedies. To protect ourselves, we must transcend the narrow interests that have historically stood in the way of a coherent oil security strategy and implement policies that will meaningfully address both the supply and demand aspects of our current oil dilemma.[55.2]

This study was not conducted by some fringe group or obscure participants; it was carried out by individuals with premier levels of education and direct experience serving the government at the highest levels. And yet, despite their stark warnings of our country's vulnerability to reductions in oil supply and their clarion call to action, two years after the publication of this report nothing has been done. Whether the drop in supply comes as a consequence of disruptions above ground or as a result of declining supplies below ground, the result on the global economy is the same. It is beyond question that immediate action to mitigate this vulnerability is required. But as hard as it might be to imagine, the threat to the economy may not be the greatest danger we face.

Unexpected Danger

Thus far this paper has primarily focused on the geological issues involving the possibility of peak oil, the difficulty with gearing up alternative energy sources in a timely manner, and the overall economic damage that could be done. Generally speaking most of us don't have a lot of trouble understanding the danger to the economy because we understand that oil means transportation. But there is one other significant issue to take into consideration when contemplating the impact of a terminal decline in fossil fuels: the danger to food production.

Other than agriculture specialists and plant biologists, few of us are aware of the role played by petroleum in our food system. We tend to think farming and crop yields as products of the tractor, irrigation, and a farmer's hard work. But in fact, without petroleum, we would only be able to produce a fraction of today's crop yields. Some of the reasons are obvious and understandable: mechanization of farm equipment fueled by gas or diesel fuel permits large tracts of land to be farmed by very few workers; electric generators running on diesel are used to power the pumps to irrigate huge fields; machines (running on fossil fuels) process the food; and trucks and other delivery vehicles of every sort distribute food between the various stops of processing until the consumer drives it home from the grocery store. But that is only part of the story, and statistically speaking, not the most critical.

Though mechanization of farming played a significant role in the increasing of man's ability to increase crop production, the driver for increasing yields on the same patch of land is due to a combination of bioengineering and petroleum inputs. According to a July 1997 United States Department of Agriculture (USDA) report entitled, "Agricultural Resources and Environmental Indicators, 1996-97," petroleum inputs were responsible for the significant increases in crop production in what became known as the "Green Revolution." The report begins by explaining that from the settlement of the US until the 19th Century, virtually all increases to crop production came as the result of increasing the cropland used. But of the quadrupling of production since then, it states:

> As manufacturing developed, production of chemical fertilizers like superphosphates and, later, urea and anhydrous ammonia replaced most fertilizers produced from recycled wastes. Commercial fertilizers provided low-cost nutrients to help realize the yield potential of new crop varieties and hybrids (Ibach and Williams, 1971). Since 1960, yields per unit of land area for major crops have increased dramatically. For example, average corn yield has increased from 55 bushels per acre in 1960 to 139 bushels in 1994 and average wheat yield from 26 to 38 bushels per acre (fig. 3.1.1). If nutrients were not applied, today's crops would rapidly deplete the soil's store of nutrients and yields would plummet.[56]

The significance of that last sentence? The nutrients cited in the foregoing are almost all petroleum-derived. The importance of those inputs was made even more clear in an updated version of the USDA publication in 2003. The report opened by celebrating the achievements of the American agricultural community in continuing annual increases in productivity, stating that "U.S. agricultural output grew at an average rate of 1.89 percent annually from 1948 to 1996, entirely due to productivity growth."[57] However, in a subsequent section of the report a notable fact was included as to the engine upon which that increase was fueled:

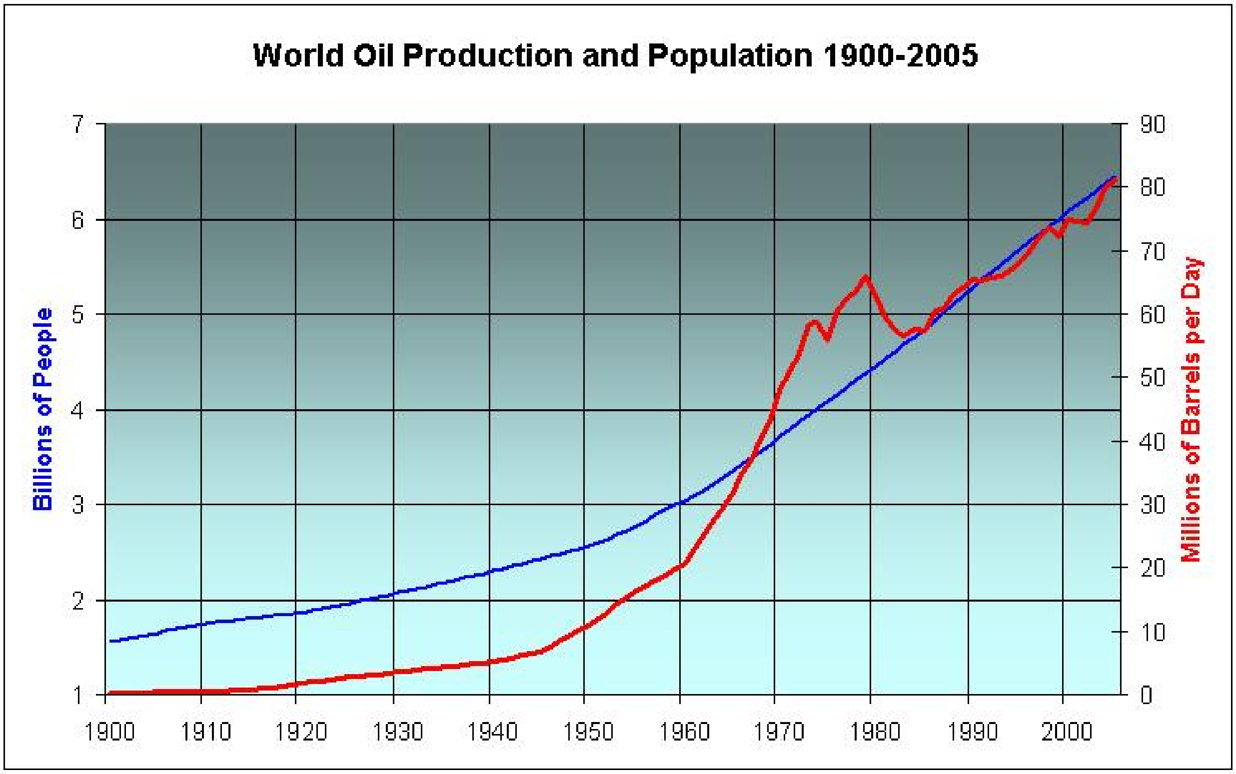
> Larger shifts occurred in particular inputs over 1948-96. Although intermediate inputs (fertilizers, pesticides, energy, feed, seed, and livestock) as a group increased 1.42 percent per year over the period, energy inputs increased less than 0.9 percent while pesticides increased at nearly 5 percent per year. Synthetic pesticides were just beginning to be used in the late 1940's, but adoption occurred rapidly, and by the early 1970s, most acres in major crops were being treated. Total pounds of pesticides applied peaked in the early 1980's, and have been relatively stable since then.[58]

It is crucial to note that energy inputs increases almost one percent per year, and pesticides increases an average of 5% per year for the 48 years of the study. What would happen if those inputs were suddenly curtailed one to two percent per year? What about a decade later when they were reduced 10-20%? 40-50%? The 1996 report explicitly stated that if the inputs were not applied, "yields would plummet." When we likewise consider the compounding issues like the impact of decreasing fuel supply to power the irrigation pumps – or fuel for the tractors and combines, for the transport rigs, the delivery trucks, and other declining-fuel supplies issues – it becomes clear that food production would become severely crimped by declining oil production. To further compound the situation, while the production of crude oil declines, the population will continue to rise.

Population Effects

Consider that from the year zero until 1850 the global population increased from about 300 million to 1.5 billion – an average increase of about 65 million *per century*.[59] From 1850 to 2006, the increase was from 1.5 billion to 6.5 billion – an average of 32 million *per year*. But in just the 12 years from 1987 to 1998, the population increased from five to six billion for an average of 83 million per year, or *18 million more than previously increased in a century*.

As seen on the below graph,[60] the global explosion of population since 1900 has roughly tracked the rise of the oil age, and since the mid 1980s, has exactly mirrored the growth in crude production. Why are these facts significant when discussing peak oil? Because far and away the primary driver for the "Green Revolution" have been its petroleum-based inputs; without these inputs it would be impossible to generate the volume of produce per acre of ground we currently enjoy. If petroleum inputs decline, so too will the ability to produce food, and at a correlation comparable with the ascension.



Source: Paul Chefurka

According to the United Nations Population Division,[61] global population is expected to rise at fairly predictable rates over the next several decades, though less steeply than experience during the 20th Century. In the table below we see historical figures from the year zero to the present and future projections through the year 2050.

World Population

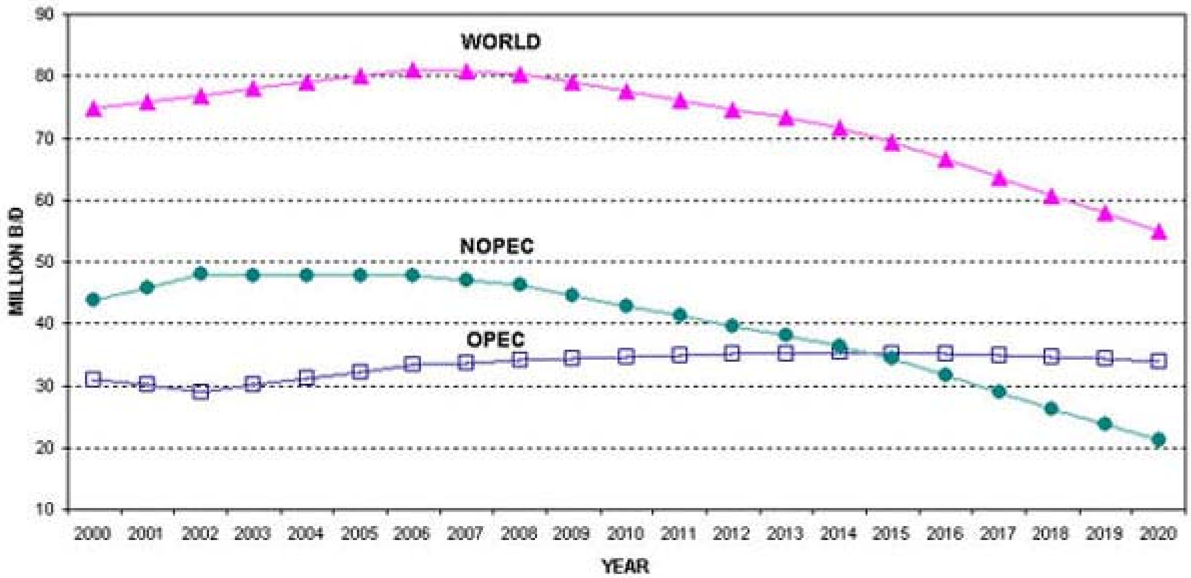
Year	Population (in billions)
0	.30
1000	.31
1250	.40
1500	.50
1750	.79
1800	.98
1850	1.26
1900	1.65
1910	1.75
1920	1.86
1930	2.07
1940	2.30

1950	2.52
1960	3.02
1970	3.70
1980	4.44
1990	5.27
1999	5.98
2000	6.06
2010	6.79
2020	7.50
2030	8.11
2040	8.58
2050	8.91

Source: United Nations Population Division

Next, notice the graph below depicting the oil depletion curve presented by Dr. A.M. Samsam Bakhtiari, former senior executive at the National Iranian Oil Company, at the International Oil Conference in Copenhagen, Denmark on December 10th, 2003.[62] Particularly note the barrels of oil projected for the year 2020 – approximately 55mbd. Now look back up at the World Oil Production and Population graph, and read down the right hand column and find 55mbd, which last occurred in 1985. Next read over to the left hand side of the graph to ascertain what the population was the last time the world saw production of 55mbd: approximately 4.75 billion. Again, note that from 1985 through 2006 the line of population increase and million barrels per day of oil production have been virtually identical. Now lets look forward again to the year 2020.

Dr. Bakhtiari projects global production of 55mbd in 2020. Looking back to the UN population projection for the same year we find the expected population is 7.5 billion people – three billion more people to feed as the last time the world produced this amount of oil. I chose this model to demonstrate (though there are many others with similar projections) because of the location of the peak: the year 2006. When one considers that in 2003 Dr. Bakhtiari predicted that the peak would occur in 2006 and at approximately 83mbd – and then combined with the fact that since June of 2004 global production has plateaued at approximately 85mbd[63] (more on that in a subsequent section) – his projections of future production must also be given serious consideration.



Source: Dr. Samsam Bakhtiari

Richard Heinberg, author of "The Party's Over: Oil, War and the Fate of Industrial Societies," posits that when the oil runs completely out (potentially well into the 22nd Century), the earth's human carrying capacity would be dramatically less than today. Such circumstances would necessitate the "culling" as he put it, of billions of people between now and then. "At the end of the day," he wrote, "we are still left with something like two billion as an educated guess for planet Earth's sustainable, long-term, post-petroleum carrying capacity for humans. This poses a serious problem, since there are currently nearly six-and-a-half billion of us, and our numbers are still growing."[64]

In a December 2005 paper written by Permaculturalist Jay Tomczak, the system upon which America's food system depends must be transformed quickly to avoid the danger that will follow when petroleum inputs begin to diminish. According to Tomczak:

> The U.S. food system has gone through three main periods; expansion, intensification and saturation. The development of these periods has brought the current food system to a state of dependence on non-renewable fossil fuels. Natural gas is required for synthetic nitrogen fertilizer and oil is required for the transport of farm inputs and outputs. These fossil fuels are finite resources and mounting evidence supports the hypothesis that their production will soon go into terminal decline. The current food system is also degrading the natural systems it depends on for its existence. The main conclusions of this study are; (A) The current food system is unsustainable because it is overly dependent on non-renewable fossil fuel resources which will soon become more scarce (B) This posses a threat to food security, because with the current system, fossil fuel supply shortages mean food supply shortages (C) To insure food security the current food system should be transformed into a system that efficiently uses local renewable energy, enhances the regeneration of renewable resources and is ecological sustainable.[65]

Although it is uncertain whether the absence of petroleum inputs will affect crop yields as seriously as suggested by Heinberg and Tomczak, one thing is for sure: if petroleum inputs permit croplands to produce four times today what they were prior to 1850, it is clear that without such inputs the output will be less, reducing the planet's carrying capacity and its ability to feed the population. How much smaller is a profoundly important question that must be determined quickly.

For these reasons it is crucial that agricultural experts, biologists, biological engineers, and chemists be charged immediately to begin exhaustive studies to firmly calculate the role petroleum plays in our food production, determine what effect will be suffered when the inputs begin to dwindle, what mitigating measures must be implemented and finally, to begin an earnest search for replacements to fossil fuel inputs that will enable us to maintain current yields.

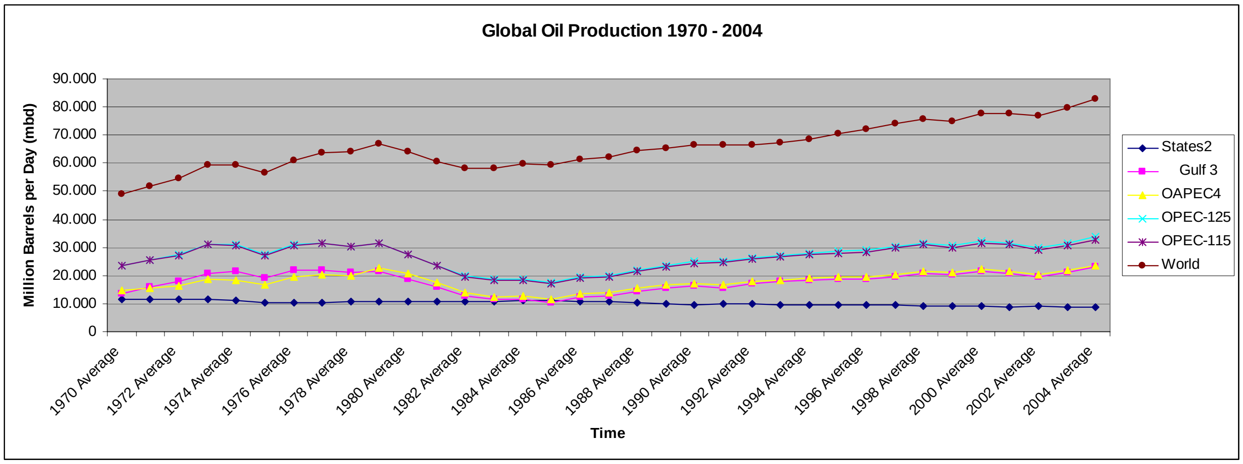
While these facts portend a dire future, a bit of encouragement might be in order: man's capacity to solve challenging problems. As has been the case since the dawn of mankind, when faced with overwhelming problems, man is capable of great feats: *there's nothing like the prospect of one's death to focus the mind*. There is little doubt that when the reality of the decline of oil begins to soak into the public consciousness, the best efforts of our finest minds, national governments, and billions of dollars of investment will materialize and mitigating solutions will be found. However, even the good news is tempered: the longer we wait to begin that intensive effort and significant investment, the narrower the gap between discovery of the problem and the onset of its consequences.

Current Evidence

Thus far this paper has dealt with theoretical future issues regarding the peaking of crude oil. We will now shift our attention to the present, and to physical evidence.

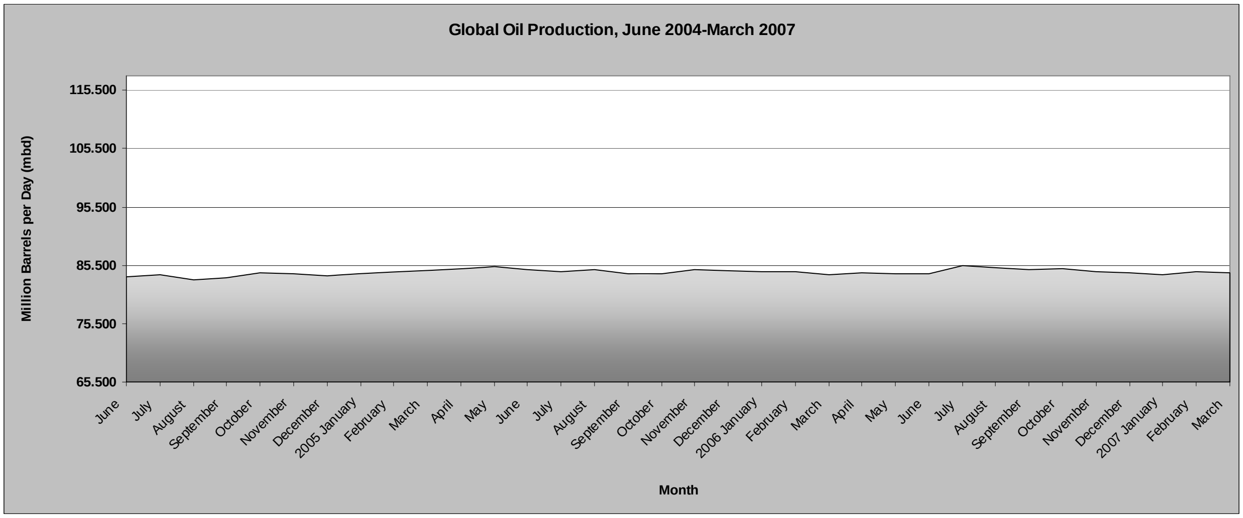
Despite all the claims of virtually inexhaustible supplies of oil, for the past 34 consecutive months – when global demand has been rising – production has flat-lined.[66] The implications of this fact are troubling. Particularly when one considers that from 1900 to 1975, global oil production increased at an average of 6.5% per year. Then from 1982 to 2005, the number dropped to only 1.2% per year[67] – and according to the EIA, global production has seen virtually no increase for the 34 months June 2004 through March 2007. These are facts, not suppositions or theory: since June 2004 global oil production has plateaued.[68]

To graphically demonstrate the change, look at the below chart showing annual global production from 1973 to 2004. You see a steady, if uneven, increase over time from 49mbd to approximately 84mbd.



Source: Energy Information Administration (US DOE), 2007

Next we examine the 34 months from June 2004 through March 2007. You will see virtually no change. And yet over this same period of time global demand has increased faster than originally predicted. A June 12, 2007 Financial Times article reported that supply in the second half of 2007 could be even tighter. "David Fyfe, an analyst at the IEA [International Energy Agency] said: 'We would very much hope that Opec production is at its seasonal low at the moment… We definitely do need more crude oil.' The IEA now expects demand for oil to rise by 1.7 m barrels a day this year compared to last year – an increase of about two per cent."[69] But as shown on the above graph, there has been no increase for almost three years. As Mr. Fyfe points out, the hope is that OPEC can simply open the spigots and produce more. But what if the world in aggregate cannot produce more?



Source: Energy Information Administration (US DOE), 2007

Less than a month later another Financial Times article reported that a combination of tightening supplies and faster-than-expected depletion in existing fields was causing alarm among many in the oil industry. "In its starkest warning yet on the world's fuel outlook, the International Energy Agency said 'oil looks extremely tight in five years time' and there are 'prospects of even tighter natural gas markets at the turn of the decade'. The IEA said that supply was falling faster than expected in mature areas, such as the North Sea or Mexico, while projects in new provinces such as the Russian Far East, faced long delays. Meanwhile consumption is accelerating on strong economic growth in emerging countries."[69.4] If demand is increasing faster than expected, supplies are being used up quicker than predicted, and existing oil fields are depleting faster than predicted, it is possible the peak of oil may already have been reached.

This possibility provides a compelling reason for immediate action. If the current production indeed represents the global peak, then every day we delay in committing significant resources and mental energy to developing a new strategy is one day we'll descend deeper into crisis when the decline in production begins. Viewing the totality of evidence at hand, and considering the cost and lead-time necessary to create the technological infrastructure to permit alternatives to have an impact, we have no time to lose and must act now.

Recommendations

Toward that end, I make the following recommendations for immediate action; first for the US Government and second for the petroleum industry.

The Government

For the Government, I urgently recommend that a series of detailed studies be conducted at a minimum by the departments and agencies listed below. These organizations will conduct thorough analysis in their areas of expertise to assess the impact a terminal decline in fossil fuel production would have. In order to organize and coordinate their efforts, the Department of Homeland Security must take the lead in coordinating all actions. Each department should conduct their analysis using the same gradient of decline in determining the impact. Each organization must respond to their specific requirements by addressing the result in the following gradient: "What would be the consequences to the issues under consideration if: 1) a one to two percent annual decrease in global oil production occurred through the first five years following the peak? Next, project the consequences that will occur when oil production has been reduced to 2.) 10%. Then at 3) 15%, 4) 20%, 5) 25%, 6) 50%, and 7) 75%.

At a minimum, the US Government should direct the following studies to be conducted:

1. **Department of Energy** must conduct an exhaustive study to identify how the web of oil is intertwined throughout the American society; what products or by-products are produced directly or indirectly from petroleum products? What impact would a reduction in oil have in the construction and maintenance of the road system (asphalt is oil-based)? What level of development would need to be achieved to allow oil shale to be produced to meaningful levels? How much money would the federal budget need to allocate to this purpose?

2. **United States Department of Agriculture** must conduct a detailed analysis of the role petroleum products play in our food system. Specifically, delineate the role of petroleum in every component of the production of food from tilling the soil, planting the seeds, supporting the growth, harvest, transport to processing plant, into temp storage, to the

retail outlet, to the dinner table and into the stomach. Moreover, the USDA should conduct or sponsor a Hirsch Report-like study to specifically identify mitigating actions or alternative inputs to maintain current crop yields in the absence of petroleum inputs, how readily available the feed stock would be for such alternatives, what level of investment would be necessary, and how much time would it take industry to gear up to permit sufficient quantities to be produced?

3. **Government Accountability Office** must produce a comprehensive analysis that identifies the greatest sources of wasted energy in this country, and enumerates how we could enact conservation measures. This will be one of the most important studies because it will need to be applied first; it will take significant time before meaningful action can result from the other studies recommended here, but one of the first orders of the day once the peak has occurred will be to begin immediate conservation of existing energy consumption. Every area of energy usage in this country will be on the table. One of the requirements for this study is an emergency energy conservation plan that could be executed on demand.

4. **Department of Transportation** must conduct a study to determine the impact of peak oil on transportation in the United States; a separate study will be conducted for the airline industry, which could be at particular risk.

5. **Department of the Treasury** must conduct an analysis of how peak oil would impact the US and Global economy. Since petroleum has so many direct inputs to industry, this will be one of the more difficult studies to produce but most crucial to have.

6. **Department of Labor** must assess how a damaged economy would effect the unemployment rate? How would the government respond to that increase? How would the job market change? What new industries could be created? How would the service industry be affected when consumer disposable income dries up?

7. **Social Security Administration** must conduct a thorough analysis of the impact on the nation's retirees if the economy goes into recession or depression as a result of the peak of oil. Particularly with large numbers of Baby Boomers reaching retirement age in the near future, what would be the impact on the Government's ability to provide payments and services?

8. **Department of Commerce** must study the impacts of declining global oil supply on international trade, specifically as it relates to imports and exports to and from the US.

9. **Department of Defense**: it is critical that DoD examine its future weapons development programs. According to recent GAO reports, the DoD has an astounding $1.5 trillion dollars in planned investment for new weapon systems.[69.5] In an unconstrained economic environment such levels might be possible, but if the peak of oil were reached and the economy damaged, the US Government would not be able to support this level of spending. It is critical, then, that DoD begin making contingency plans on how modernization would continue in a severe budget-constrained environment.

Additionally, the direction of this modernization would have to be reassessed in light of the likelihood of a decreased amount of petroleum product to fuel its aircraft and combat vehicles.

10. **Environmental Protection Agency** must work together with DoE and assess the difficulties in producing meaningful amounts of petroleum product from America's enormous oil shale deposits in a way that will not cause more harm to society than the good that will result from an increase to the domestic oil supply. It is crucial that we put our best efforts into ensuring that we concurrently develop a plan to produce oil from shale at the same time as we develop a plan to deal with the impact on the water supply and the tons of waste produced.

Petroleum Industry

The oil majors (ExxonMobil, Shell, Texaco, etc) do not have to view this process as antagonistic to their interests – though they presently do. In fact, shortly after President Bush's 2007 State of the Union address when he announced his "Twenty in Ten" initiative to mandate that biofuels compose 20% of the gasoline supply within 10 years and his intention to strengthen the Corporate Average Fuel Economy (CAFE) Standards,[70] the industry immediately fired a warning shot across the Administration's bow by threatening to withhold planned increases in gasoline refinery production facilities. A June 17th Associated Press article entitled, "Oil Industry Scales Back Refinery Plans" quoted Chevron vice chairman Peter Robertson as saying, "Why would I invest in a refinery when you're trying to make 20 percent of the gasoline supply ethanol?"[71] The answer for industry is not to withdraw from investment, but to direct it into more appropriate applications.

As previously mentioned, the RAND study unequivocally states that there is presently no effort underway to build the industrial-scale infrastructure necessary to produce meaningful quantities of oil from shale. This absence of insufficient research and development must end. Since it is the oil companies themselves that will reap the profits of turning shale (and other non-conventional oil sources) into usable oil, they must immediately apply significant research and development funds into ascertaining the most cost effective and environmentally safe methods of converting raw shale into usable crude.

Following the oil crisis of the 70s, many companies made significant investments into oil shale production, but when the price of oil dropped in the second quarter of 1986 from $32 to $13 per barrel[72] and cheap and easy crude glutted the market, all R&D dried up as it was clearly no longer cost effective. Those dynamics have changed, and changed forever. It is now time – past time – for the oil industry to gear up new, significantly funded research and development programs focused on creating new sources of fuel that will not cost more energy to make than is produced, and which will not cause more damage to the environment than we can afford.

The Petroleum industry should not shy away from these kinds of investments; they should embrace them. These organizations by and large already possess the requisite level of expertise to discover new, cost effective sources of energy, and have a great deal to gain from their development. With the price of oil already above $70 and climbing, the economics are fertile for industry investment. Now is the time.

These Government studies and industry initiatives are crucial to gaining a clear, sober understanding of what the impact of peak oil would be on the United States. Without such information, decision-makers will only have subjective reports (like this one) that are based on surface analysis; facts, as revealed through detailed and exhaustive study are required. As mentioned, these studies must be coordinated through a newly created sub-organization of the Department of Homeland Security and their scope and suspense date be proscribed by the Department and then appropriate recommendations for action be made to the President and Congress. But it is crucial that these studies not be conducted as an end to themselves: *they must result in action*.

Leadership

There is only one way we can accomplish that goal, however: Leadership. Unless decisive leadership is provided, not one element of this report will result in meaningful action. That fact is evidenced by the growing number of peak oil studies that have recently been written by nationally and internationally known authors, and yet no action of consequence has resulted. Australia and England seem to be further along than the United States, as coalitions of governing authorities in those countries have at least formed to begin discussions, but even in those cases no action has resulted.

Simply having more committees and study groups won't help us when the peak occurs. One of the key findings of the Oil Shockwave study cited earlier was the need for action: "The challenge is to act now to develop long-term policies and to create more effective options for managing the medium-term impacts – years 2 through 10 – of a major oil crisis… Addressing this vulnerability constitutes one of the preeminent energy, economic, and national security challenges of our time we must act now."[72.5] We need action. We need *leadership.* But given recent history, I fear that most likely there will be no action or leadership; only more talk and obfuscation.

I base my pessimism on the recent performances of our government. And let me begin by clearly pointing out that the examples of failures that follow are not party-centric: it wasn't "the Republicans" it wasn't "The Administration," "Congress," "the Dems" or any other category – it was an across the board failure of leadership at all levels of government from top to bottom, across party lines. In other words, the failure has been with *us.* Almost no hands are clean. Unless we roll up our sleeves and get this done right, the cost to us all in a post-peak world will be far more than simple finger-pointing.

A brief review of the more egregious failures:

Katrina

On August 29, 2005 a Category 4 hurricane blew into the US Gulf Coast and laid waste to significant portions of the Mississippi and Louisiana coast and famously destroyed the levies protecting New Orleans, creating catastrophic flooding that killed many and dislocated thousands. Compounding the natural disaster was the debacle of the response. Plans for dealing with disasters like that had existed at virtually all levels of government: national, state, and local. In the days leading up to August 29th, there were many warnings that a Category 4 storm was approaching, giving authorities critical time to make last minute assessments of the plans and what they would do if disaster struck. But the minds of the leaders – at all levels – could not fathom the scale of the disaster and made inadequate preparations. When the worst case scenario actually played out, it quickly overwhelmed the combined capabilities of the US Government, the State of Louisiana, and the City of New Orleans. And this was a single city, affected by a single event.

September 11

In an attempt to find out how the United States could have been taken by such surprise by the terrorist attacks of September 11, 2001, the US Government established "The 9/11 Commission" to conduct a comprehensive analysis. Particular criticism was levied upon key Administration officials as well as the CIA and FBI. The report claimed that numerous officials and organizations possessed sufficient knowledge on the plot and that had they taken action early enough, the attacks might have been preempted.

Operation Iraqi Freedom and Phase IV

Bob Woodward's 2007 book "State of Denial" chronicles the Administration's preparation for and conduct of Operation Iraqi Freedom. What becomes clear from reading Woodward's account, is that a large number of key Government and Military officials grossly underestimated the scale and difficulty of conducting so-called "Phase IV" operations after the conventional combat phase had been completed. In the first few years after the invasion, the Administration was often accused of not having a plan for post-combat Iraq. As Woodward points out in detail, it wasn't that the Administration failed to plan – they did have a plan – it was that their plan was grossly inadequate and did not provide solutions for issues that were known before hand, and should have devoted more resources to finding a solution.

Conclusion

The consistent factor in all the above was the inability of Government officials at all levels to properly assess the seriousness of the issue when time was available to take appropriate action. Had FEMA Director Michael Brown realized the magnitude of the problems associated with a Category 4 hurricane plunging into New Orleans, he would have mobilized his assets much earlier, in larger volume, and more quickly after the storm than he did; Had George Tenet really believed that Al Qaeda was preparing an attack within the United States, he would not have remained silent when Condoleezza Rice allegedly ignored his warnings; had Donald Rumsfeld listened to those that predicted the US would not be welcomed in 2003 Iraq as liberators but rather opposed as occupiers, he would have put a great deal more effort into Phase IV planning and an entirely different outcome might have played out.

But in all cases, key officials grossly underestimated the gravity of the impending problem, even when credible information was given them that argued to the contrary. We are in just such a situation now.

Presently there is sufficient information available warning that a problem exists, but too little detailed information upon which decision-makers could act. It is critical, therefore, that the recommendations to conduct detailed analysis previously cited be initiated immediately. We must have the most qualified experts in various fields ascertain the consequences that would occur if the global supply of crude oil began to decline as a result of depletion. Only if our leaders – and the American people – are armed with facts and information can we make the rational decisions necessary to prepare for what lies ahead.

It is a documented fact that we failed in adequately preparing for the September 11 attacks; we failed in adequately preparing for the Katrina hurricane; we failed in our appreciation of the difficulty of post-war Iraq: we can not fail to prepare for post-peak oil

In closing, I include the following quotes from two reports issued this year; the first from the latest of the three Hirsch Reports, and the second from the GAO. Both of these reports will be useful to the post-peak commission that will be formed to determine how we so badly missed the warning signs before the onset of the peak. These two reports will be used as evidence that reports were conducted, measures recommended, but no action taken:

Hirsch 2007: *It is our sincere hope that readers will look beyond the conflicting forecasts and focus on the consequences of underestimating the enormity of the peak oil problem. Effective mitigation means taking decisive action well before the problem is obvious*.[73]

GAO 2007: *While public and private responses to an anticipated peak could mitigate the consequences significantly, federal agencies currently have no coordinated or well-defined strategy either to reduce uncertainty about the timing of a peak or to mitigate its consequences. This lack of a strategy makes it difficult to gauge the appropriate level of effort or resources to commit to alternatives to oil and puts the nation unnecessarily at risk*.[74]

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modest 0.5% annual decrease in production for the fields in decline over the 23 years between now and 2030 (0.5% over 23yrs = 11.5% total decrease), we arrive at a figure of 5.9mbd (85mbd X .60 X .115). Thus, we calculate a rounded average of 6mbd.

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