PEAK OIL: ALTERNATIVES, RENEWABLES, AND IMPACTS

Clifford J. Wirth, Ph.D.

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www.peakoilassociates.com
clifford.wirth@peakoilassociates.com

ABSTRACT

This paper examines scientific and government studies in order to provide reliable conclusions about Peak Oil and its future impacts. Independent studies indicate that global oil production peaked in 2006 (or will peak within a few years) and will decline until all recoverable oil is depleted within several decades. Because global oil demand is increasing, declining production will soon generate high energy prices, inflation, unemployment, and irreversible economic depression. Regardless of the time available for mitigating Peak Oil impacts, alternative sources of energy will replace only a small fraction of the gap between declining production and increasing demand. Because oil under girds the world economy, oil depletion will result in global economic collapse and population decline. As oil exporting nations experience both declining oil production and increased domestic oil consumption, they will reduce oil exports to the U.S. Because the U.S. is highly dependent on imported oil for transportation, food production, industry, and residential heating, the nation will experience the impacts of declining oil supplies sooner and more severely than much of the world. North American natural gas production has peaked, importation of natural gas is limited, and the U.S. faces shortages of natural gas within a few years. These shortages threaten residential heating supplies, industrial production, electric power generation, and fertilizer production. Because U.S. coal production peaked in 2002 (in terms of energy provided by coal), the U.S. will experience significantly higher coal and electric prices in future years. The U.S. government is unprepared for the multiple consequences of Peak Oil, Peak Natural Gas, and Peak Coal. Multiple crises will cripple the nation in a gridlock of ever-worsening problems. Within a few decades, the U.S. will lack car, truck, air, and rail transportation, as well as mechanized farming, adequate food and water supplies, electric power, sanitation, home heating, hospital care, and government services.

INTRODUCTION

In a 1977 address to the nation, President Carter warned that the U.S. faced a "national catastrophe" unless we adopted strict conservation measures to reduce the rapid depletion of oil and natural gas reserves. This warning was ignored and the catastrophe is now imminent.

Oil and natural gas under gird manufacturing, transportation, employment, building construction, cement manufacturing, central heating and air conditioning, as well as the world's food production (planting, irrigating, harvesting, processing, and providing petrochemicals for fertilizers, pesticides, and herbicides). Oil provides the raw materials for manufactured products, including plastics, tires, paints, latex, chemicals, asphalt, synthetic fabrics, building materials, Styrofoam, Formica, medicines, and some 300,000 other products. Oil and natural gas are the life blood for economic development, urbanization, globalization, technology, a high standard of living, leisure time, health care, nutrition, travel, control of infectious diseases, solid waste removal, water purification, water distribution, and waste water treatment.

This paper reviews scientific and governmental studies concerning: oil and natural gas production and depletion; the potential for developing alternative energy sources, and the economic, political, and social consequences of oil and natural gas depletion.

With the assistance of a panel of 13 energy scientists of the National Academy of Sciences, the U.S. Government Accountability Office (GAO) recently examined the issue of declining oil production in "Crude Oil: Uncertainty about the Future Oil Supply Makes it Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production" (2007). This study concludes:

> "Because development and widespread adoption of technologies to displace oil will take time and effort, an imminent peak and sharp decline in oil production could have severe consequences. The technologies we examined [ethanol, biodiesel, biomass gas-to-liquid, coal gas-to-liquid, and hydrogen] currently supply the equivalent of only about 1% of U.S. annual consumption of petroleum products, and DOE projects that even under optimistic scenarios, these technologies could displace only the equivalent of about 4% of annual

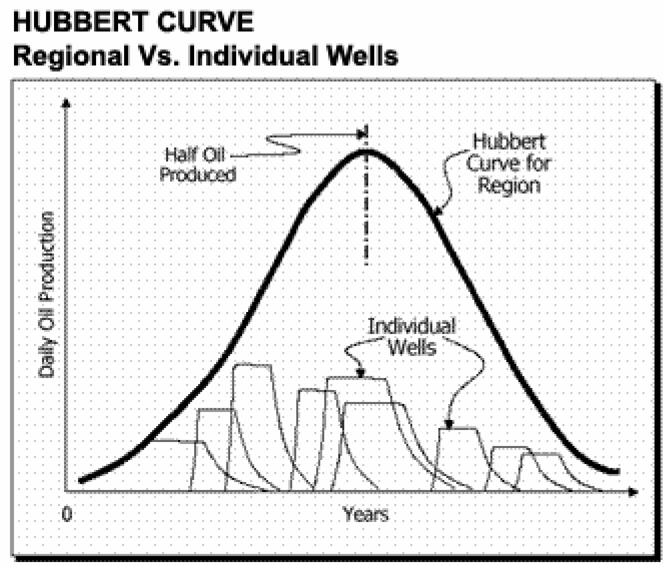
> projected U.S. consumption by around 2015. If the decline in oil production exceeded the ability of alternative technologies to displace oil, energy consumption would be constricted, and as consumers competed for increasingly scarce oil resources, oil prices would sharply increase. In this respect, the consequences could initially resemble those of past oil supply shocks, which have been associated with significant economic damage. For example, disruptions in oil supply associated with the Arab oil embargo of 1973-74 and the Iranian Revolution of 1978-79 caused unprecedented increases in oil prices and were associated with worldwide recessions. In addition, a number of studies we reviewed indicate that most of the U.S. recessions in the post-World War II era were preceded by oil supply shocks and the associated sudden rise in oil prices. Ultimately, however, the consequences of a peak and permanent decline in oil production could be even more prolonged and severe than those of past oil supply shocks. Because the decline would be neither temporary nor reversible, the effects would continue until alternative transportation technologies to displace oil became available in sufficient quantities at comparable costs. Furthermore, because oil production could decline even more each year following a peak, the amount that would have to be replaced by alternatives could also increase year by year."

PEAK OIL PRIMER

In 1977, the National Academy of Science and National Academy of Engineering (NAS/NAE), assisted by a team of 350 prominent scientists from universities, government, and industry, completed a comprehensive study of energy policy, "Energy in Transition 1985-2010." This study predicted that global oil and natural gas production would peak in the 1990s and then decline steadily. Due to slow global economic growth in the late 1970s and 1980s, the actual peak was pushed back some years. The NAS/NAE study recommended strong conservation measures as well as the development of solar power, nuclear power, and liquid fuels derived from coal and solar energy. The business sector, media, universities, and public ignored these warnings. The U.S. now faces global Peak Oil production, depletion of oil and natural gas reserves, and economic decline that will deepen over time. Within a few decades, economically recoverable reserves of oil and natural gas will be exhausted, resulting in global economic collapse and population decline. The Association for the Study of Peak Oil and Gas (see their ASPO Newsletter), and Energy Watch Group provide detailed studies of Peak Oil.

Energybulletin.net provides an explanation of the Peak Oil crisis (excerpts):

> “*Peak oil* is the simplest label for the problem of energy resource depletion, or more specifically, the peak in global oil production. Oil is a finite, non-renewable resource, one that has powered phenomenal economic and population growth over the last century and a half. The rate of oil 'production,' meaning extraction and refining (currently about 85 million barrels/day), has grown in most years over the last century. Once we have used about half of the original reserves, oil production becomes ever more likely stop growing and begin a terminal decline, hence 'peak'. Peak oil means not 'running out of oil', but 'running out of cheap oil'. For societies leveraged on ever increasing amounts of cheap oil, the consequences may be dire. Without significant successful cultural reform, economic and social decline seem inevitable. [Current global oil production is 85 million barrels per day; the U.S. consumes 21 million barrels per day, which equals 25% of global production.]
>
> Why does oil peak? Why doesn't it suddenly run out?
>
> Oil companies have, naturally enough, extracted the easier-to-reach, cheap oil first. The oil pumped first was on land, near the surface, under pressure, light and 'sweet' (meaning low sulfur content) and therefore easy to refine into gasoline. The remaining oil is more likely to be off-shore, far from markets, in smaller fields, or of lesser quality, and therefore takes ever more money *and energy* to extract and refine. Under these conditions, the rate of extraction inevitably drops. Furthermore, all oil fields eventually reach a point where they become economically, and energetically, no longer viable. If it takes the energy of a barrel of oil to extract a barrel of oil, then further extraction is pointless, no matter what the price of oil.
>
> M. King Hubbert – the first to predict an oil peak
>
> In the 1950s a U.S. geologist working for Shell Oil Company, M. King Hubbert posited that the rate of oil production would follow a curve, now known as the Hubbert Curve (see figure).



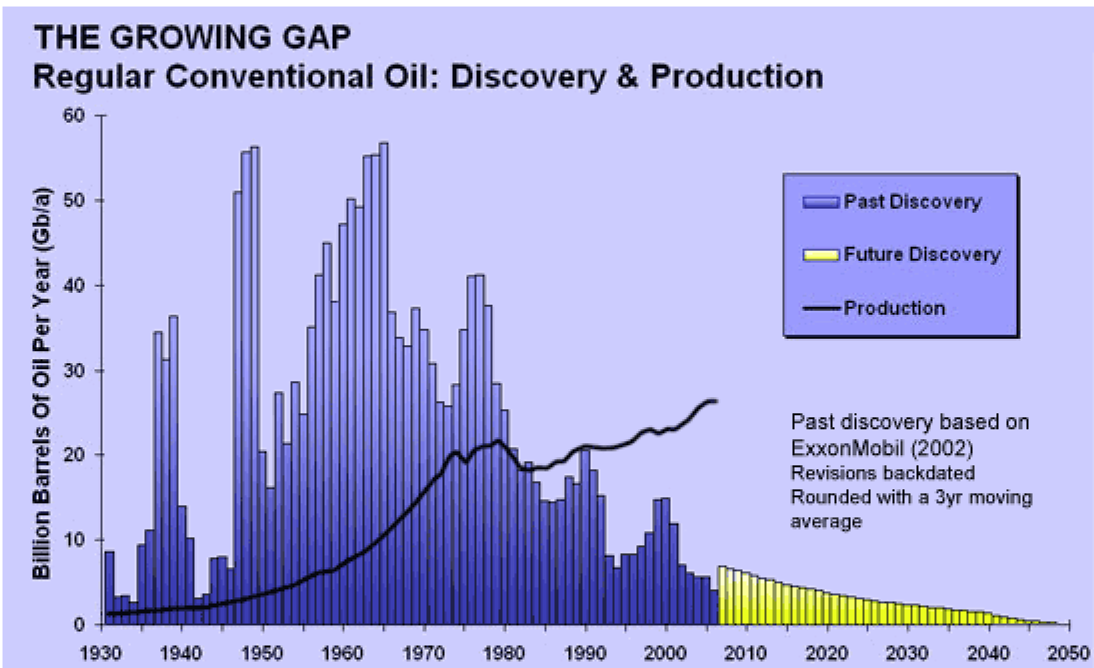
In 1956 Hubbert predicted that production from the US lower 48 states would peak between 1965 and 1970. Shell tried to pressure Hubbert into not making his projections public, but the notoriously stubborn Hubbert went ahead and released them. In any case, most people inside and outside the industry quickly dismissed Hubbert's predictions. It turned out that Hubbert was right; US continental oil production did peak in 1970. However in 1970, by definition, US oil producers had never produced as much oil and Hubbert's predictions were a fading memory. The peak was only recognised several years later with the benefit of hindsight.

No oil producing region fits the bell shaped curve exactly because production is dependent on various geological, economic and political factors, but the Hubbert Curve remains a powerful predictive tool.

Although it passed by largely unnoticed by many, the U.S. oil peak was arguably the most significant geopolitical event of the mid to late 20th Century, creating the conditions for the energy crises of the 1970s, leading to far greater U.S. strategic emphasis on controlling foreign sources of oil, and spelling the beginning of the end of the status of the U.S as the world's major creditor nation. The U.S. of course was able to import oil from elsewhere, and life continued there with only minimal interruption. When global oil production peaks however, the implications will be far greater.

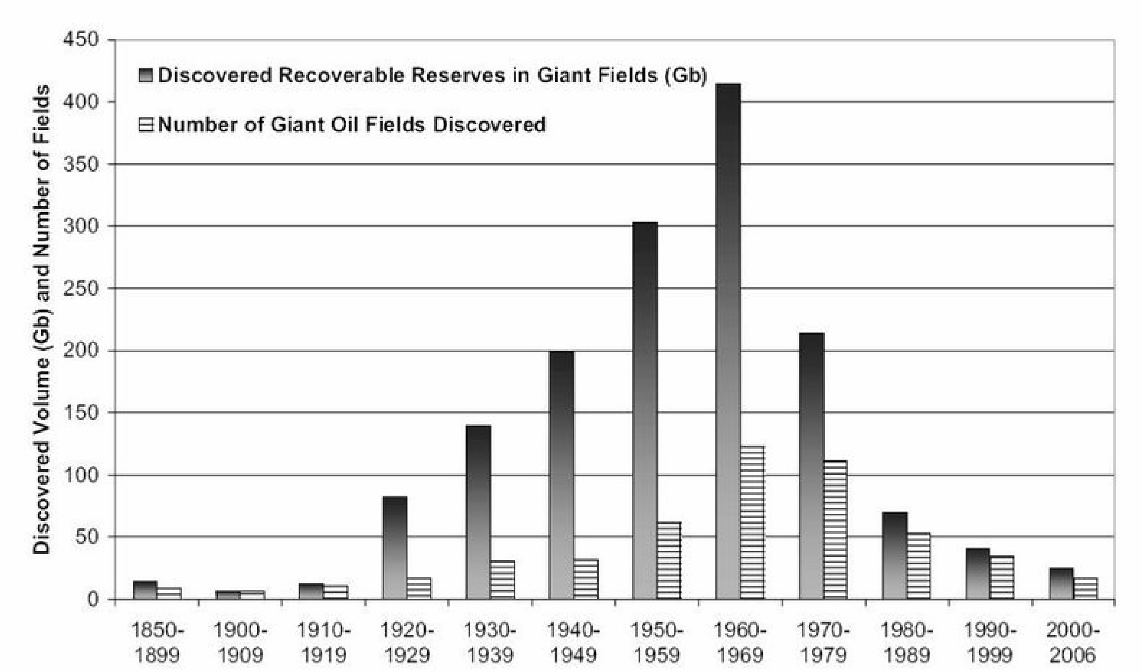
So when will oil peak globally?

Hubbert went on to predict a global oil peak between 1995 and 2000. He may have been close to the mark except that the oil shocks of the 1970s slowed our use of oil. As the following figure shows, global oil discovery peaked in the late 1960s. Since the mid-1980s, oil companies have been finding less oil than we have been consuming.



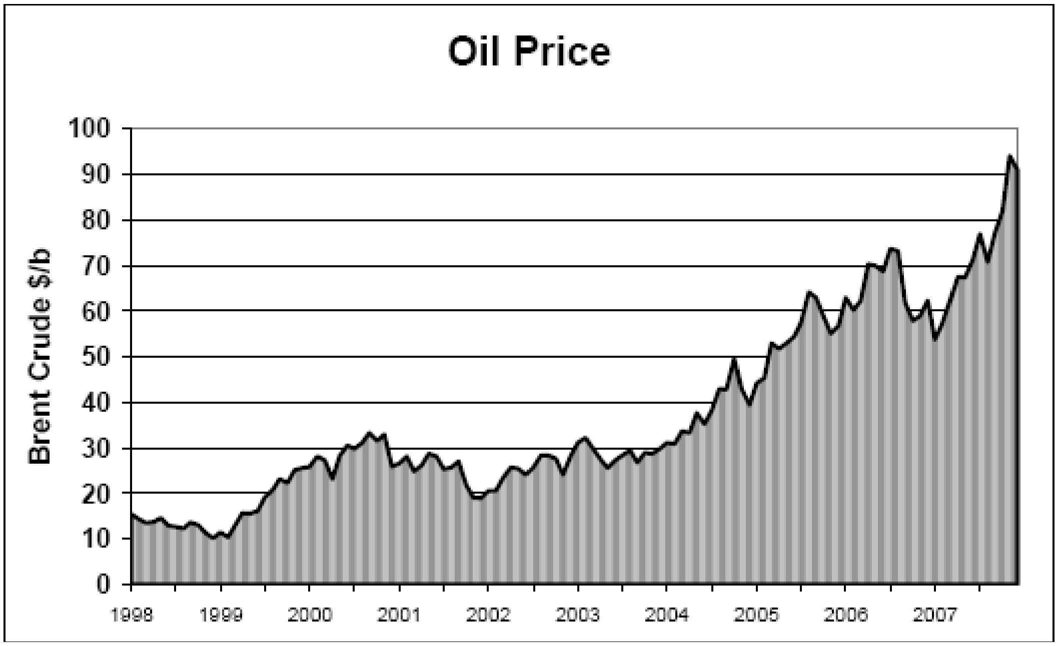
Source: ASPO Ireland, 2007. Permission to publish.

World Discoveries of Giant Oil Fields



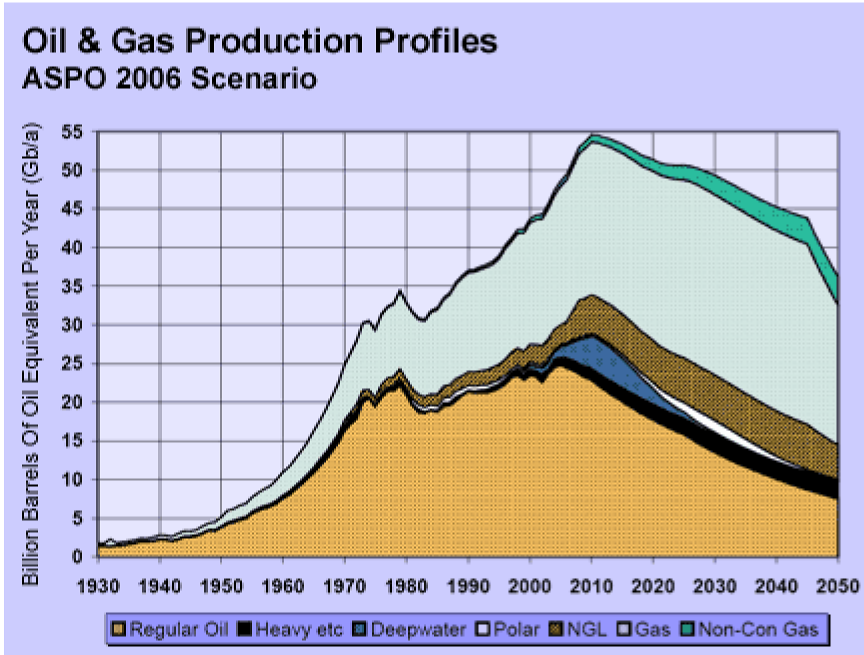
Source: Fredrik Robelius, "Giant Oil Fields – The Highway to Oil," 2007. Permission to publish.

Of the 65 largest oil producing countries in the world, up to 54 have passed their peak of production and are now in decline, including the USA (in 1970) and the North Sea (in 2001). Hubbert's methods, and variations on them, have been used to make various projections about the global oil peak, with results ranging from 'already peaked', to the very optimistic 2035. Many of the official sources of data used to model oil peak such as OPEC figures, oil company reports, and the USGS discovery projections, upon which the international energy agencies base their own reports, can be shown to be very unreliable. Several notable scientists have attempted independent studies, most notably Colin Campbell and the Association for the Study of Peak Oil and Gas (ASPO).



Oil prices reached $100 per barrel in early January 2008. Source: ASPO Ireland, January 2008. Permission to publish.

ASPO's latest model suggests that 'regular' oil peaked in May 2005. If heavy oil, deepwater, polar and natural gas liquids are considered, the oil peak is projected for around 2010 [many analysts indicate this peak occurred in 2006, to be discussed later in this paper]. Combined oil and gas, as shown below, are expected to also peak around 2012. Other researchers such as Kenneth Deffeyes and A. M. Samsam Bakhtiari have produced models with similar or even earlier projected dates for oil peak. Precise predictions are difficult as much secrecy shrouds important oil and gas data.

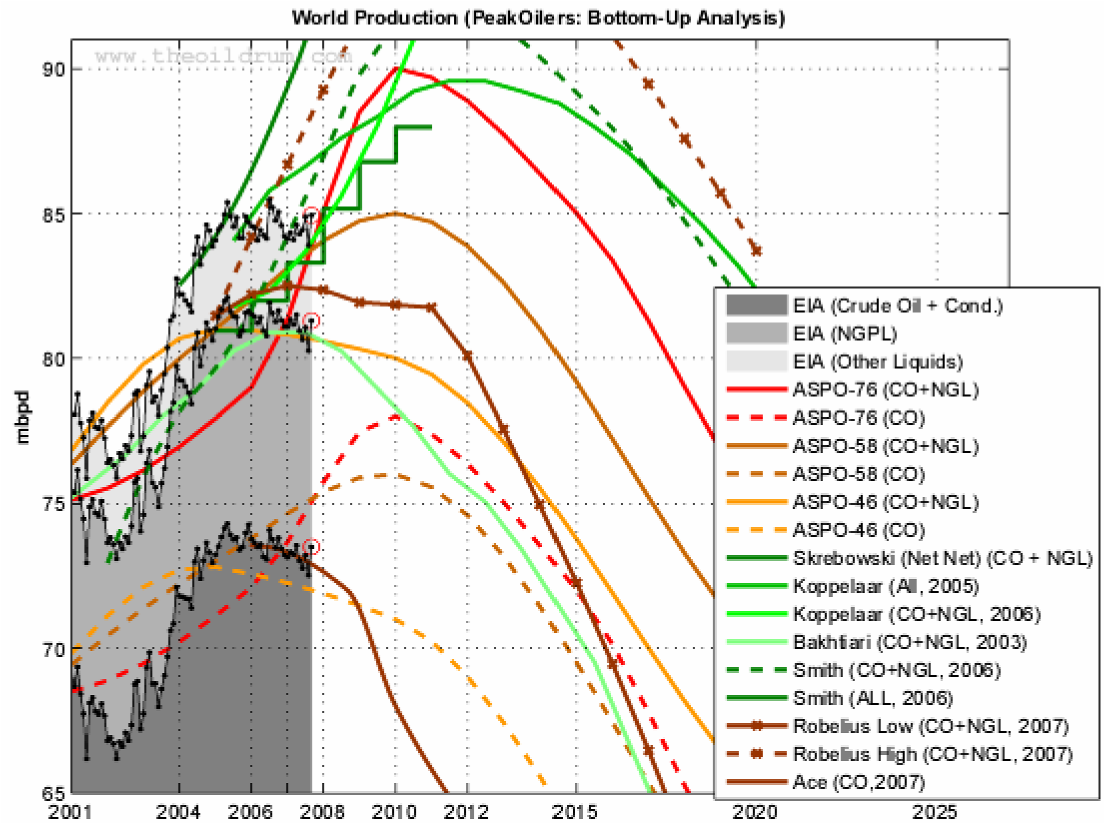


Source: ASPO Ireland. Permission to publish.

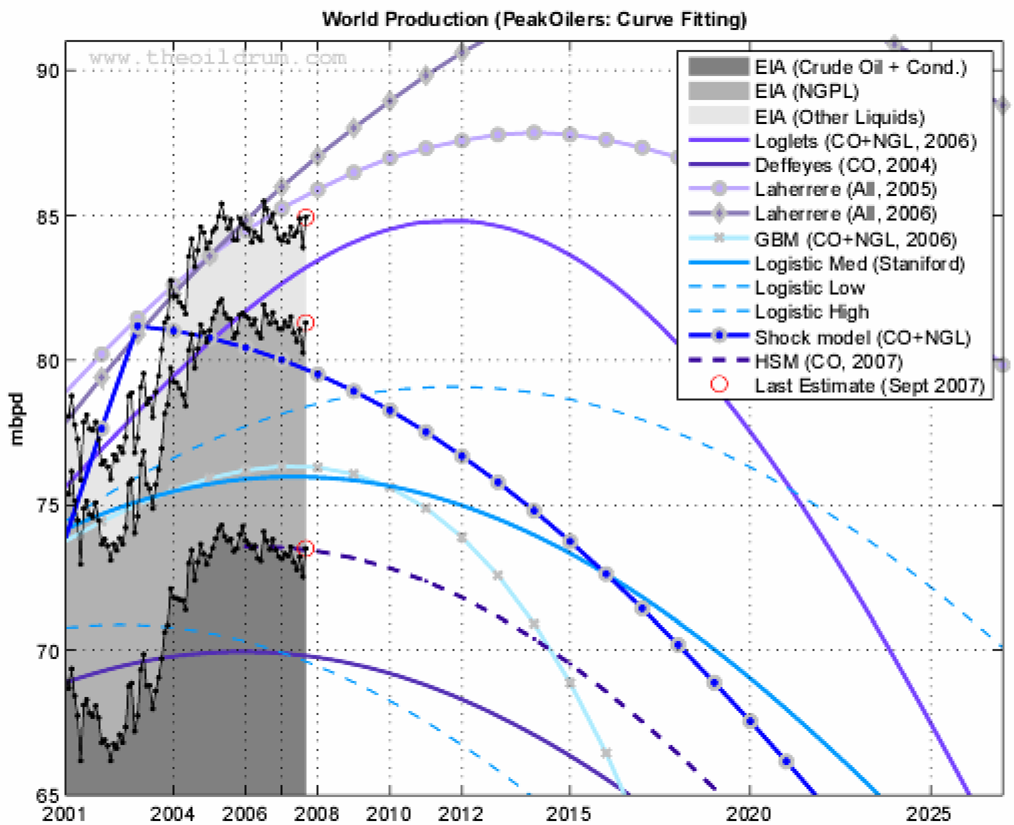
The effects of natural gas peak are more localized due to the economic and energetic expense of liquefying and transporting natural gas as LNG. Both British and U.S. natural gas production have already peaked, so these nations may be facing dual energy crises."

PAST THE PEAK

Many independent analysts conclude that oil production will peak sometime between 2005 and 2010, as shown in the figures below.



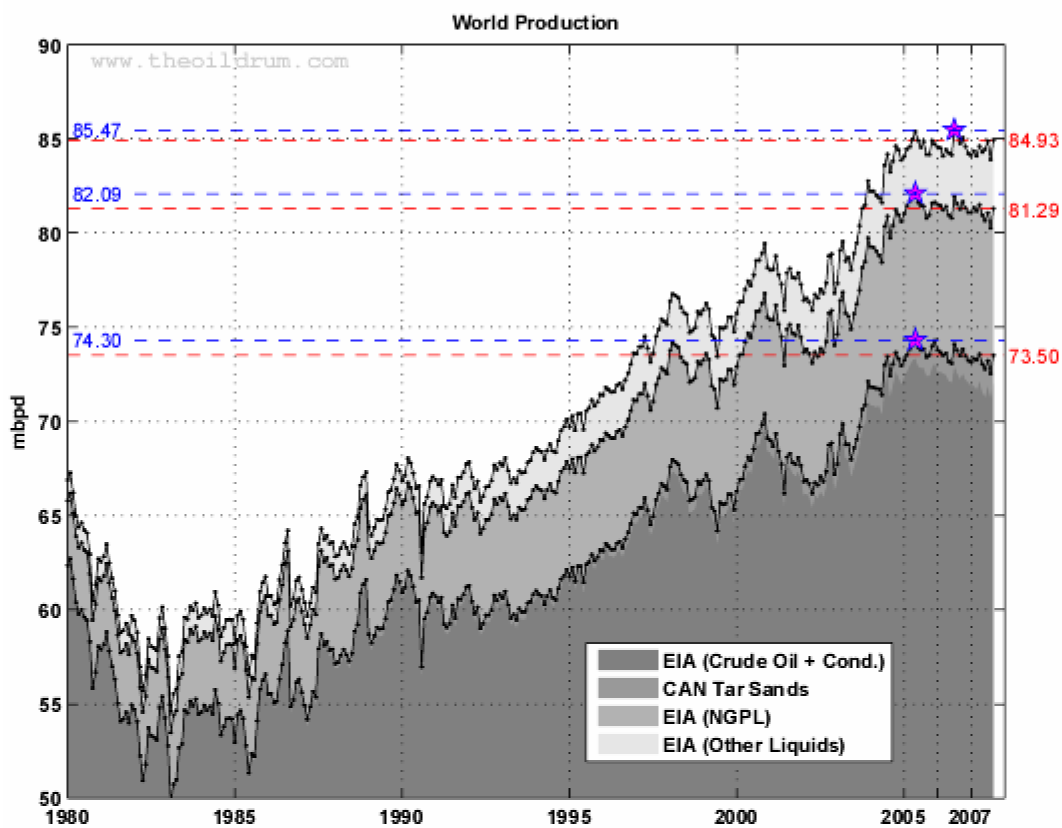
Forecasts by Peak Oil analysts (December 2007) (bottom-up methodologies). Shaded areas indicate past production levels. Source: Khebab. Theoildrum.com. Permission to publish.



Forecasts by Peak Oil analysts (December 2007) (curve fitting methodologies). Shaded areas indicate past production levels. Source: Khebab, Theoildrum.com. Permission to publish.

See also the forecasts in a study prepared by Robert L. Hirsch and commissioned by the National Energy Technology Laboratory of the U.S. Department of Energy. All of the above studies take into account: possible oil and gas discoveries in Polar Regions, the Arctic National Wildlife Refuge, deep water sources, the Gulf of Mexico etc., as well as advancements in drilling and enhanced oil recovery (EOR) technology.

Several analysts conclude that world crude oil production has already peaked. Based on U.S. Energy Information Administration (EIA) data (Table 1.1d World Crude Oil Production 1997-Present), Kenneth S. Deffeyes concludes that global "crude oil" production peaked in May of 2005, with a plateau in 2006 and 2007. He notes that with the high profits generated by oil prices between $50 and $85 per barrel in 2006 and 2007, "virtually all producers pumped every possible barrel," and that production in 2006 [and 2007] was slightly below that of 2005. EIA data (Table 1.4 World Oil Supply 1997-Present) suggest that global "oil production" (includes crude oil, natural gas condensates, heavy oil and oil sands, and other liquids) peaked in July 2006; specifically, global oil production increased steadily from 74 million barrels per day in 1997 to 85.5 million barrels in 2006, but then plateaus slightly lower in 2007. Also see Khebab for an analysis of EIA data.



"World production (EIA data, December 2007). Blue lines and pentagrams are indicating monthly maximum. Monthly data for Crude Oil from the EIA. Annual data for NGPL and Other Liquids from 1980 to 2001 have been upsampled to get monthly estimates." Source: Khebab. Theoildrum.com. Permission to publish.

Other observers who conclude that global oil production has peaked include the late Dr. A. M. Samsam Bakhtiari, former senior energy expert for National Iranian Oil Co. (NIOC) of Tehran, Matthew Simmons, chairman of Simmons & Co. International in Houston and former advisor to the Bush administration (also see Simmons' website), T. Boone Pickens, chairman of BP Capital Management, the German based Energy Watch Group, and Sadad Al Husseini, former head of exploration and production for Saudi Aramco.

Rembrandt Koppelar of Oil Watch Monthly (concluded that production of crude oil and total liquids could increase slightly above these levels in the next few years. Colin Campbell of ASPO concludes that the peak will occur in 2010. Fredrik Robelius' exhaustive study of oil fields globally indicates a peak occurrence between 2008 and 2018. The 2018 peak prediction is based on optimistic production scenarios, including substantially increased production of Canadian oil sands (but in 2006 the Canadian government indicated this was unlikely). Several other studies have concluded that the peak will occur after 2010. Cambridge Energy Research Associates' (CERA) optimistic peak prediction of 2030 or later is based on questionable analysis. CERA counts as "reserves" great quantities of oil that will not be recovered due to technical limitations, high production costs, and high energy usage in extractive processes. CERA counts oil shale as unconventional oil reserves. Objective sources, however, such as the U.S. General Accountability Office and the World Energy Council, have concluded that extracting carbon from oil shale is not economically viable because its production consumes great quantities of energy and requires major capital investments. For discussions of CERA's projections, see Chris Skrebowski's "Open Letter to Peter Jackson of CERA," Dave Cohen's "Does the Peak Oil Myth Just Fall Down? – Our Response to CERA," and "CERA Ignores Ten Warning Signposts of Peak Oil" by Udall, Gilbert, and Andrews. Because CERA is a consulting firm that serves energy industry clients (who would naturally prefer optimistic scenarios in order to assure stockholders that they are making secure investments in oil), there are concerns of bias regarding CERA's optimistic energy projections. Journalist Tom Whipple reported that 1,600 CEOs, sheiks, professors, analysts, and energy decision makers paid up to $5,500 each to attend a recent CERA conference. CERA has, in fact, recently criticized the Peak Oil theory, despite the fact that the 1977 NAS/NAE study established Peak Oil as a scientific fact (none of the NAS/NAE scientists questioned the science of Peak Oil). Robert Hirsch notes that unless CERA can provide better data, the Robelius study should stand as the forecast that the world should use for risk management planning for Peak Oil.

The optimistic assessments of the U.S. Energy Information Administration, (EIA) International Energy Administration (IEA) and U.S. Geological Survey (USGS) are flawed, because they use highly questionable foreign government data which are known to be inflated, and they overestimate the amount of reserve oil that is recoverable (see the critiques of USGS, IEA, and EIA forecasts by Zittel, Schlinder, Systemtechn). In its "Medium Term

Oil Market Report" (July 2007), the IEA reversed its traditionally optimistic projections: "Despite four years of high oil prices, this report sees increasing market tightness beyond 2010, with OPEC spare capacity declining to minimal levels by 2012." The EIA and USGS are not independent agencies like the GAO, National Academy of Science, National Academy of Engineering, and the Congressional Research Service; rather, the EIA and the USGS report to the Secretaries of the Departments of Energy and Interior, both of whom are influenced by the energy industry. The GAO tacitly rejected the Peak Oil timing assessments of the EIA and USGS and recommended that these agencies undertake studies that would reduce uncertainty about the timing of Peak Oil.

The GAO offered no assessment concerning the specific timing of Peak Oil, even though they could have asked their 13 member NAS panel to address this question. The GAO reported solely on published sources and thus ignored recent studies posted on the Internet, where most analysts provide the most recent information about the timing of Peak Oil.

SUPPLIES, DEMAND, AND RAPID DEPLETION

Several factors contribute to the Peak Oil crisis. First, global demand for oil is growing rapidly. The U.S. Energy Information Administration predicts that global oil demand will grow from 85 million barrels per day in 2006 to 97 million barrels per day by 2015 and to 118 barrels in 2030. Second, production costs grow exponentially as depletion progresses. The remaining oil is of lower quality and must be extracted from deeper in the earth, often in deep water and ultra deep water off-shore sites. The GAO study notes that, "there is great uncertainty about the amount of oil that will ultimately be produced, given the technological, cost, and environmental challenges." Third, as depletion progresses more and more energy must be expended to extract, transport, and refine lower quality oil that contains less and less energy. Chris Shaw explains this "quicksand effect" in interesting detail. Finally, because many oil exporting nations are experiencing both depletion and increased domestic consumption, these exporting nations will soon reduce exports (see research by Rembrandt Koppelaar and Jeff Rubin). For example, in 2007 the Mexican government announced that due to declining production and increased domestic consumption, Mexico will reduce oil exports to the U.S. by 150,000 barrels per day on the average over the next four years, by 500,000 for the following two years, and that its oil reserves will be depleted by 2014. Likewise, analysts cited in "The Wall Street

Journal" indicate that Mexico could become an oil importer by 2015. According to the Oil Depletion Analysis Center (ODAC), Great Britain will become an oil importer after 2009. Finally, resource nationalism, war, sabotage, terrorism, and political instability threaten oil supplies. As the GAO noted, 60% of world oil reserves are "in countries where relatively unstable political conditions could constrain oil exploration and production." Former CIA director James Woolsey has explained how easily armed attacks can cut oil supplies from the Middle East. A variety of analysts are concerned about blockage of the Strait of Hormuz, through which passes two fifths of the globally traded oil.

WHAT DOES PEAK OIL MEAN FOR SOCIETY?

The combination of declining oil production, increasingly more expensive oil production, and increasing world-wide demand for oil will generate enormous price increases in gasoline, diesel, heating oil, transportation, construction, manufactured goods, food, and all products that use oil for their production and/or transportation. Gasoline and diesel provide 95% of the energy for transportation. Rising inflation, high unemployment, and instability in financial markets will persist and deepen over time. High unemployment will result in mortgage payment defaults and tax delinquencies. With many homes up for sale, housing prices will plummet. Due to declining tax revenues, governments will lack the resources to provide basic services. Economic, social, and political chaos will result from the inability to address expanding problems.

Energybulletin.net explains the impacts of Peak Oil:

> "Our industrial societies and our financial systems were built on the assumption of continual growth – growth based on ever more readily available cheap fossil fuels. Oil in particular is the most convenient and multi-purposed of these fossil fuels. Oil currently accounts for about 43% of the world's total fuel consumption, and 95% of global energy used for transportation. Oil is so important that the peak will have vast implications across the realms of geopolitics, lifestyles, agriculture and economic stability. Significantly, for every one joule of food consumed in the United States, around 10 joules of fossil fuel energy have been used to produce it. In 2005 the U.S. Department of Energy released a commissioned risk mitigation study on Peak Oil by the Science Applications International Corporation (SAIC), titled

> "Peaking of World Oil Production: Impacts, Mitigation and Risk Management" [PDF]; this study is known commonly as the Hirsch Report after its primary author Robert L. Hirsch. The executive summary of the report warns that "as peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be *unprecedented*. Viable mitigation options exist on both the supply and demand sides, but to have substantial impact, they must be initiated more than a decade in advance of peaking. Unfortunately nothing like the kind of efforts envisaged has yet begun."

The Hirsch report concludes that "the world has never faced a problem like this. Without massive mitigation more than a decade before the fact, the problem will be pervasive and will not be temporary. Previous energy transitions were gradual and evolutionary. Oil peaking will be abrupt and revolutionary."

A. M. Samsam Bakhtiari writes that "The fact of being in 'Post-Peak' will bring about explosive disruptions that we know little about and which are extremely difficult to foresee. And the shock waves from these explosions rippling throughout the financial and industrial infrastructure could have myriad unintended consequences for which we have no precedent and little experience."

In testimony before the Subcommittee on Energy and Air Quality, U.S. House of Representatives (7 December 2005) U.S. Representative Roscoe Bartlett (Republican, Maryland) stated: "How and when we as individuals and government leaders will respond to global 'Peak Oil' is what we need to address immediately. I believe global 'Peak Oil' presents our country with a challenge as daunting as the one that faced the astronauts and staff of the Apollo 13 program" [the Apollo 13 astronauts narrowly escaped death on the journey back to earth in 1970].

ALTERNATIVES INSUFFICIENT

The sections below provide documentation and explanations concerning limitations of alternative energies.

The 2007 U.S. General Accountability Office examined the potential of alternative energies for replacing liquid fuels (liquid fuels are vital for transportation and food production):

> "The technologies we examined [ethanol, biodiesel, biomass gas-to-liquid, coal gas-to-liquid, oil shale, and hydrogen] currently supply the equivalent of only about 1% of U.S. annual consumption of petroleum products, and DOE projects that even under optimistic scenarios, these technologies could displace only the equivalent of about 4% of annual projected U.S. consumption by around 2015… Furthermore, because oil production could decline even more each year following a peak, the amount that would have to be replaced by alternatives could also increase year by year."

Solar energy (defined here as wind, solar thermal, photovoltaics, and hydroelectric [hydroelectric is considered solar energy because the sun drives the climate which provides water power])

The Union of Concerned Scientists (an organization of scientists and citizens [based at the Massachusetts Institute of Technology] who promote renewable energy sources and conservation) concluded in "Renewing Where We Live" (2003) that the U.S. could "achieve 20% of electric supply from renewables by 2020" (including hydroelectric power). This would reduce natural gas consumption (used for generating electricity) by 6%. Because natural gas provides 23% of total energy supply, this is a little more that 1% of total energy supply (6% X 23% = 1.38%). Because hydroelectric dams are ecologically damaging to rivers and estuaries (artificial lake creation, higher water temperatures, eutrophication, and loss of habitats and farms lands), both the Union of Concerned Scientists and the NAS/NAE study oppose the expansion of this source. And there are few rivers remaining that can be dammed for hydroelectric power generation.

Physicist Howard C. Hayden concludes that solar and wind power are limited for several reasons. (1) Solar and wind energy are dispersed. For example, to provide the equivalent of one 1,000 megawatts of power plant in California would require a wind farm one mile wide from Los Angeles to San Francisco (or a 127 square mile area of solar mirrors to generate the heat needed for a turbine). (2) Areas with ample sun light or wind are limited (for example, sunlight is weak in winter months in northern states). (3) Extensive solar and wind mill operations would have negative ecological impacts. (4) Much energy is consumed in the construction and maintenance of solar panels, wind turbines, and power line infrastructure that extends to far away cities uses.

Biofuels

The Union of Concerned Scientists concluded that:

> "Even if we used all our corn to make ethanol, with nothing left for food or animal feed, we could only displace perhaps 1.5 million barrels per day of this demand [U.S. consumption is 21 million barrels per day]. Clearly, corn ethanol is a part of the solution but by itself is not a sufficient long-term solution to our oil dependence. Ethanol is currently transported mainly by tanker truck or rail cars because it cannot be shipped in existing gasoline pipelines. The potential capacity for ethanol production from corn is fairly limited. In addition to concerns about feedstock limitations, *corn ethanol derives much of its energy from fossil fuel inputs."* (Emphasis added).

In fact, a thorough study by Tad W. Patzek reveals that there is no net energy gain from the production of corn ethanol.

A 2007 study by the U.S. Congressional Research Service, "Ethanol and Biofuels: Agriculture, Infrastructure and Market Constraints Related to Expanded Production" concluded:

> "While recent proposals have set the goal of significantly expanding biofuel supply in the coming decades, questions remain about the ability of the U.S. biofuel industry to meet rapidly increasing demand. Current U.S. biofuel supply relies almost exclusively on ethanol produced from Midwest corn. In 2006, 17% of the U.S. corn crop was used for ethanol production. To meet some of the higher ethanol production goals would require more corn than the United States currently produces, if all of the envisioned ethanol was made from corn. Due to the concerns with significant expansion in corn-based ethanol supply, interest has grown in expanding the market for biodiesel produced from soybeans and other oil crops. However, a significant increase in U.S. biofuels would likely require a movement away from food and grain crops. Other biofuel feedstock sources, including cellulosic biomass, are promising, but technological barriers

> make their future uncertain. Issues facing the U.S. biofuels industry include potential agricultural "feedstock" supplies, and the associated market and environmental effects of a major shift in U.S. agricultural production; the energy supply needed to grow feedstocks and process them into fuel; and barriers to expanded infrastructure needed to deliver more and more biofuels to the market….There are limits to the amount of biofuels that can be produced and questions about the net energy and environmental benefits they would provide. Further, rapid expansion of biofuel production may have many unintended and undesirable consequences for agricultural commodity costs, fossil energy use, and environmental degradation. As policies are implemented to promote ever-increasing use of biofuels, the goal of replacing petroleum use with agricultural products must be weighed against these other potential consequences."

Hydrogen

In 2004, the National Academy of Engineering identified significant problems with a hydrogen economy in, The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs:

> "There are major hurdles on the path to achieving the vision of the hydrogen economy; the path will not be simple or straightforward. Many of the committee's observations generalize across the entire hydrogen economy: the hydrogen system must be cost-competitive, it must be safe and appealing to the consumer and it would preferably offer advantages from the perspectives of energy security and CO_2 emissions. Specifically for the transportation sector, dramatic progress in the development of fuel cells, storage devices, and distribution systems is especially critical. Widespread success is not certain. The committee believes that for hydrogen-fueled transportation, the four most fundamental technological and economic challenges are these:

1. *To develop and introduce cost-effective, durable, safe, and environmentally desirable fuel cell systems and hydrogen storage systems.* Current fuel cell lifetimes are much too short and fuel cell costs are at least an order of magnitude too high. An on-board vehicular hydrogen storage system that has an energy density approaching that of gasoline systems has not been developed. Thus,

the resulting range of vehicles with existing hydrogen storage systems is much too short.

2. *To develop the infrastructure to provide hydrogen for the light-duty-vehicle user.* Hydrogen is currently produced in large quantities at reasonable costs for industrial purposes. The committee's analysis indicates that at a future, mature stage of development, hydrogen (H_2) can be produced and used in fuel cell vehicles at reasonable cost. The challenge, with today's industrial hydrogen as well as tomorrow's hydrogen, is the high cost of distributing H_2 to dispersed locations. This challenge is especially severe during the early years of a transition, when demand is even more dispersed. The costs of a mature hydrogen pipeline system would be spread over many users, as the cost of the natural gas system is today. But the transition is difficult to imagine in detail. It requires many technological innovations related to the development of small-scale production units. Also, nontechnical factors such as financing, siting, security, environmental impact, and the perceived safety of hydrogen pipelines and dispensing systems will play a significant role. All of these hurdles must be overcome before there can be widespread use. An initial stage during which hydrogen is produced at small scale near the small user seems likely. In this case, production costs for small production units must be sharply reduced, which may be possible with expanded research.

3. *To reduce sharply the costs of hydrogen production from renewable energy sources, over a time frame of decades.* Tremendous progress has been made in reducing the cost of making electricity from renewable energy sources. But making hydrogen from renewable energy through the intermediate step of making electricity, a premium energy source, requires further breakthroughs in order to be competitive. Basically, these technology pathways for hydrogen production make electricity, which is converted to hydrogen, which is later converted by a fuel cell back to electricity. These steps add costs and energy losses that are particularly significant when the hydrogen competes as a commodity transportation fuel—leading the committee to believe that most current approaches—except possibly that of wind energy—need to be redirected. The committee believes that the required cost reductions can be achieved only by targeted fundamental

and exploratory research on hydrogen production by photobiological, photochemical, and thin-film solar processes.

4. *To capture and store ("sequester") the carbon dioxide by-product of hydrogen production from coal.* Coal is a massive domestic U.S. energy resource that has the potential for producing cost-competitive hydrogen. However, coal processing generates large amounts of CO_2. In order to reduce CO_2 emissions from coal processing in carbon-constrained future, massive amounts of CO_2 would have to be captured and safely and reliably sequestered for hundreds of years. Key to the commercialization of a large-scale, coal-based hydrogen production option (and also for natural-gas-based options) is achieving broad public acceptance, along with additional technical development, for CO_2 sequestration.

   For a viable hydrogen transportation system to emerge, all four of these challenges must be addressed." (Emphasis added)

Since 2004, there have been no breakthroughs concerning the hydrogen economy.

Oil Shale

The World Energy Council (London, UK) makes the following assessment about the potential of oil shale energy:

> "If a technology can be developed to economically recover oil from oil shale, the potential is tantalisingly enormous. If the containing organic material could be converted to oil, the quantities would be far beyond all known conventional oil reserves. Oil shale in great quantities exists worldwide: including in Australia, Brazil, Canada, China, Estonia, France, Russia, Scotland, South Africa, Spain, Sweden and the USA.
>
> The term 'oil shale' is a misnomer. It does not contain oil nor is it commonly shale. The organic material is chiefly kerogen and the "shale" is usually a relatively hard rock, called marl. Properly processed, kerogen can be converted into a substance somewhat similar to petroleum. However, it has not gone through the 'oil window' of heat (nature's way of producing oil) and therefore, to be

changed into an oil-like substance, it must be heated to a high temperature. By this process the organic material is converted into a liquid, which must be further processed to produce an oil which is said to be better than the lowest grade of oil produced from conventional oil deposits, but of lower quality than the upper grades of conventional oil.

There are two conventional approaches to oil shale processing. In one, the shale is fractured in-situ and heated to obtain gases and liquids by wells. The second is by mining, transporting, and heating the shale to about 450^{o}C, adding hydrogen to the resulting product, and disposing of and stabilising the waste. Both processes use considerable water. The total energy and water requirements together with environmental and monetary costs (to produce shale oil in significant quantities) have so far made production uneconomic. During and following the oil crisis of the 1970's, major oil companies, working on some of the richest oil shale deposits in the world in western United States, spent several billion dollars in various unsuccessful attempts to commercially extract shale oil.

Oil shale has been burned directly as a very low grade, high ash-content fuel in a few countries such as Estonia, whose energy economy remains dominated by shale. Minor quantities of oil have been obtained from oil shale in several countries at times over many years.

With increasing numbers of countries experiencing declines in conventional oil production, shale oil production may again be pursued. One project is now being undertaken in north-eastern Australia, but it seems unlikely that shale oil recovery operations can be expanded to the point where they could make a major contribution toward replacing the daily consumption of 73 million barrels [85 million barrel in 2007] of oil worldwide.

Perhaps oil shale will eventually find a place in the world economy, but the energy demands of blasting, transport, crushing, heating and adding hydrogen, together with the safe disposal of huge quantities of waste material, are large. On a small scale, and with good geological and other favourable conditions, such as water supply, oil shale may

> make a modest contribution but so far shale oil remains the 'elusive energy'."

The 2007 GAO study concluded that, "it is possible that in 10 years from now, the oil shale resource could produce 0.5 million to 1.0 million barrels per day." But the GAO noted that the development of oil shale faces key challenges, including: "(1) controlling and monitoring groundwater, (2) permitting and emissions concerns associated with new power generation facilities, (3) reducing overall operating costs, (4) water consumption, and (5) land disturbance and reclamation."

Walter Youngquist of the Colorado School of Mines provides a detailed history and analysis of attempts to develop Colorado's oil shale. After spending billions of dollars, industry has terminated oil shale operations due to a low net energy recovery and a lack of necessary water resources.

Canadian Oil Sands

According a study by the Canadian National Energy Board, "Canada's Oil Sands, Opportunities and Challenges to 2015: An Update (2006) (the Canadian National Energy Board [NEB] is the energy regulatory agency of the Canadian national government), there are significant obstacles in reaching the production goal of 3 million barrels of oil per day by 2015:

> "The rate of development will depend on the balance that is reached between the opposing forces that affect the oil sands. High oil prices, international recognition, geopolitical concerns, global growth in oil demand, size of the resource base and proximity to the large U.S. market, and potentially other markets, encourage development. On the other hand, natural gas costs, the high light/heavy oil price differential, management of air emissions and water usage, insufficient labour, infrastructure and services are concerns that could potentially inhibit the development of the resource. There is now a clearer understanding that large water withdrawals from the Athabasca River for mining operations during the winter could impact the ecological sustainability of the river. As well, it is uncertain if land reclamation methods currently employed will be successful. These issues have moved to the forefront of environmental concerns. Regions associated with oil sands development enjoy several economic benefits but at costs to the social well-being of the

> communities, including a shortage of available housing and stress on public infrastructure and services. There is currently a limited supply of skilled workers in Alberta, and this tight labour market is expected to continue in the near future."

In November of 2007, the NEB lowered its production forecast for 2015 to 2.8 million barrels (from 3 million), due to rising costs, including competition for workers, higher provincial royalties, and environmental regulations aimed at reducing greenhouse-gas emissions.

Coal Gas-to-Liquid

In 2006, the U.S. National Coal Council proposed a program to develop a coal gas-to-liquid (GTL) plant that could generate 2.6 million barrels per day by 2020 and produce an additional 475 million tons of coal per year. The U.S. Department of Energy (DOE) has not accepted this proposal, and it is not in a planning stage of development.

The 2007 GAO study identified significant problems with the coal GTL program:

> "This fuel is commercially produced outside the United States, but none of the production facilities are considered profitable. DOE reported that high capital investments—both in money and time—deter the commercial development of coal GTL in the United States. Specifically, DOE estimates that construction of a coal GTL conversion plant could cost up to $3.5 billion and would require at least 5 to 6 years to construct. Furthermore, potential investors are deterred from this investment because of the risks associated with the lengthy, uncertain, and costly regulatory process required to build such a facility. An expert at DOE also expressed concern that the infrastructure required to produce or transport coal may be insufficient. For example, the rail network for transporting western coal is already operating at full capacity and, owing to safety and environmental concerns, there is significant uncertainty about the feasibility of expanding the production capabilities of eastern coal mines. Coal GTL production also faces serious environmental concerns because of the carbon dioxide emitted during production. To mitigate the effect of coal GTL production, researchers are considering options for combining coal GTL production with

> underground injection of sequestered carbon dioxide to enhance oil recovery in aging oil fields."

Future coal GTL is limited by the availability and rising cost of coal. The German based Energy Watch Group reported in Coal: Resources and Future Production (2007) that global coal production would peak in about 2025 "in the best case" and that,

> "The U.S. passed peak production of high quality coal in 1990 in the Appalachian and the Illinois basin. Production of sub bituminous coal in Wyoming more than compensated for this decline in terms of *volume* and – according to its stated reserves – this trend can continue for another 10 to 15 years. However, due to the lower energy content of sub bituminous coal, US coal production in terms of *energy* has already peaked 5 years ago – it is unclear whether this trend can be reversed. Also specific productivity per miner is declining since about 2000."

The Institute for Energy (IFE) of the Joint Research Centre of the European Commission, reported in The Future of Coal (2007) that (excerpts):

> "The supply base of coal is being continuously depleted. World proven reserves (i.e. the reserves that are economically recoverable at current economic and operating conditions) of coal are decreasing fast. Coal production costs are steadily rising all over the world, due to the need to develop new fields, increasingly difficult geological conditions and additional infrastructure costs associated with the exploitation of new fields."

Nuclear Power and Coal Potential for Reducing Oil Used in Electric Power Generation

There are 104 commercial nuclear generating units operating in the U.S. and the number will not increase for at least a decade. No new commercial reactor has come on line since 1996; no new plants are under construction; nor has the Nuclear Regulatory Commission granted any new construction permits for nuclear power plants. According to Platts Insight, there is renewed interest in expanded nuclear power generation. Licensing and building nuclear power plants, however, is at least a decade long process and requires major capital investments. The absence of nuclear power plant development means that for at least 10 years nuclear power will not be available for reducing the use of oil and natural gas in producing electric power.

Similarly, "The Wall Street Journal" (25 July 2007) reported that "plans for a new generation of coal-fired power plants are falling by the wayside as states conclude that conventional coal plants are too dirty to build and the cost of cleaner plants is too high." The absence of coal-fired power plant development means that for at least 10 years coal generated power will not be available for reducing the use of oil and natural gas in producing electric power.

Enhanced Geothermal Systems

According to the Geothermal Energy Association (2007), EGS currently generate 0.371% of the electric power in the U.S. New projects in 12 states will double this amount to total nearly 6,000 Megawatts of power in several years. A 2007 study by MIT, The Future of Geothermal Energy, concludes that by 2050 the U.S. could increase this amount by 100,000 MW, thus generating about 10% of the nation's electric power. Hence, EGS power will not be available for making significant reductions in the use of oil and natural gas in producing electric power for at least several decades.

Methane Hydrates

According to a 2004 study by the National Academy of Science, "Charting the Future of Methane Hydrate Research in the U.S.,"

> "Methane hydrate is a natural form of clathrate—a chemical substance in which one molecule forms a lattice around a "guest" molecule without chemical bonding. In this clathrate, the guest molecule is methane and the lattice is formed by water. Methane hydrate is formed naturally under conditions of low temperature and high pressure wherever sufficient gas exists in porewater. It has been found in Arctic regions and in marine sediment on the slopes flanking every continent.
>
> Many countries, intrigued by the widespread occurrence of natural methane hydrate and by the promising results of recent test wells in

> Japan and Canada, are looking toward gas hydrate as a potential source of energy. The U.S. in-place hydrated methane gas resource may exceed the recoverable natural gas resources of the nation. If methane can be produced from hydrate deposits, the nation's natural gas energy supply could be extended for many years to come. However, many uncertainties must be addressed before anyone will know whether gas hydrate can be produced safely and profitably. There is uncertainty in the distribution of concentrated hydrate deposits and the possibility that hydrate production could lead to pipeline and borehole instability. Uncertainties are also associated with the effect of gas hydrate on the environment. Gas hydrate may play a role relating to gas hydrate."

Because the production of methane from hydrate deposits is in the research and development phase, and because of concerns about profitability, safety, and ecological damage, for at least several decades this energy source will not provide methane (that could be utilized to reduce the consumption of oil). As of this writing, there have been no breakthroughs in extracting methane hydrates.

<u>Ocean Energy</u>

Ocean energy includes wave energy, tidal energy, ocean thermal energy conversion (OTEC), and wind energy off shore. These four technologies provide electric power. Wave, tidal, and wind are functional technologies. But due to siting requirements they are limited by their numbers; and will not generate much power. OTEC is in research and development. The author estimates that combined ocean energy power generated for the U.S. is no more than 2,000 Megawatts. In the next 10 years this figure could be tripled. Hence, ocean energy will increase power generation slightly, and it will not replace a significant amount of oil and natural gas that is used in producing electric power for at least several decades.

<u>Solar Energy from Space</u>

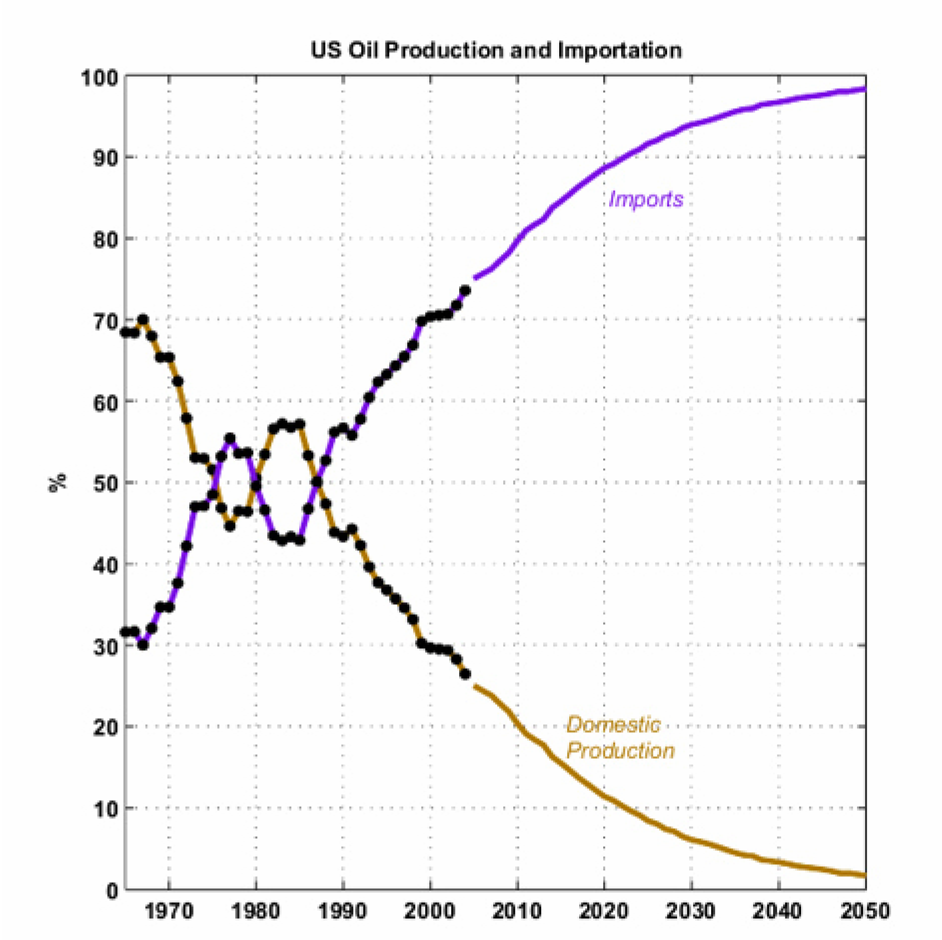
The National Security Space Office of the U.S. Department of Defense plans to study the transmission of solar energy from space (SES). The very high costs of space transport and maintenance will prohibit the commercial development of this technology. Because SES is now approaching the study phase, it would be decades until DOD could implement it.

Nuclear Fusion

For 50 years, scientists have been studying how to generate electricity from controlled fusion. Although scientists have made some progress, knowledgeable scientists in this field (Overview of Fusion Nuclear Technology in the U.S., Fusion Engineer Design 81, (2006) 33-43) conclude that any possible practical use of controlled fusion is decades away.

CONCLUSION

Global oil production peaked in 2006, or it will peak within a few years. Because the global oil demand is rising rapidly, increasing oil prices, inflation, and economic recession will accompany declining production. Because the U.S. is highly dependent on oil and highly dependent on imported oil, the U.S. will experience severe problems regarding Peak Oil. The figure below shows the widening gap between the share of imported oil and domestic oil consumed by the U.S.



Source: GraphOilogy.

Many Peak Oil writers indicate that “Peak Oil means not running out of oil, but running out of cheap oil.” Although this statement is true for the short term, the world is running out of oil in the long term. Regardless of which projection is applied, the end result is the same – terminal depletion. And because more and more oil is used in the production and processing of crude oil, there is less and less net oil produced. Oil depletion will therefore be more accelerated than projection scenarios show, and over time the oil depletion will accelerate.

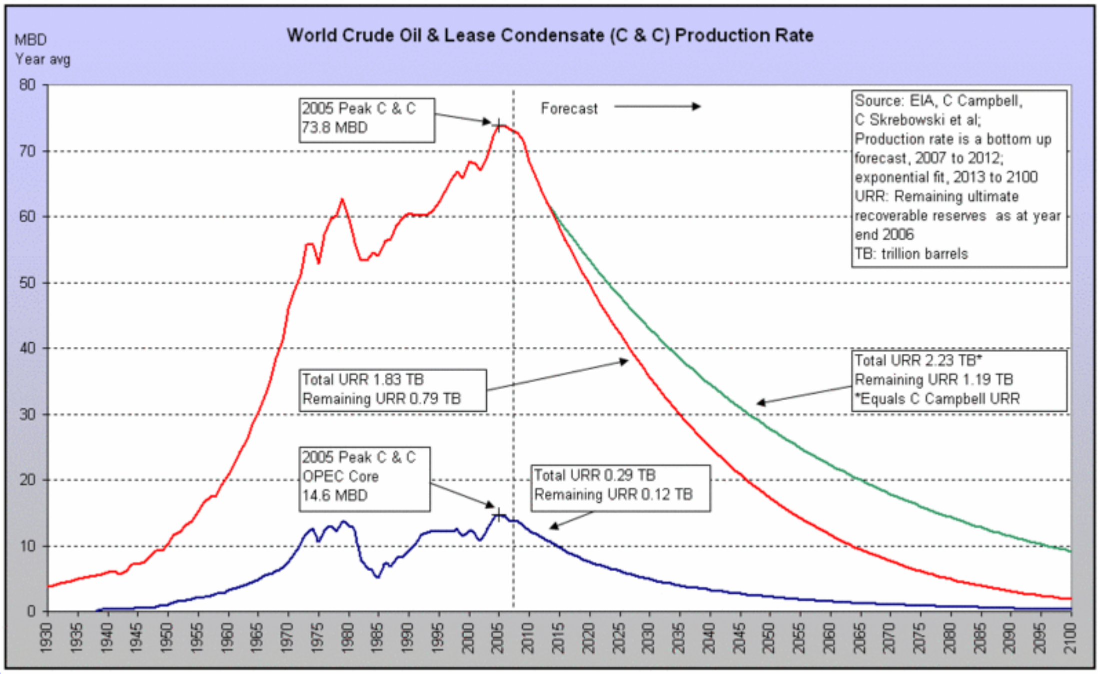
Also, because the world population is growing, the per capita consumption of oil will decline faster than the overall rate of decline, as shown in the table below:

Oil Production
(Barrels per Capita Annually)

	USA Oil Production per Capita (USA Population)	Global Oil Production per Capita (World Population)
1900	1.0	0.1
1920	4.0	0.4
1940	10.0	1.0
1960	14.5	2.5
1980	13.6	4.5
2000	7.0	4.0
2020	2.2	2.7
2040	0	1.4

Source: ASPO-Ireland. Permission to publish.

Using forecasts by ASPO, the chart below shows a global oil production projections (red line), and it includes a forecast of oil production assuming "what might be possible if the middle east gulf countries really do have the reserves close to what they have claimed, if promised production increases from heavy oil occur, and if additional significant polar oil is discovered" (green line). See also the studies by Robelius and the Energy Watch Group) which forecast more rapid depletion than ASPO. Regardless of which forecast is applied (including Ceres' forecast), the end result is the same -- terminal depletion. For the U.S., the decline in supply of oil will be far more accelerated than for the global oil depletion scenarios. As the price of oil increases, the U.S. (as world's largest debtor nation) will lack the financial resources to buy the amount of oil needed to sustain its economy. It is not clear whether the U.S. will use military power to attempt to obtain oil in the future, nor is it certain that military power would be effective in garnering oil from diverse global locations. For the most optimistic oil supply scenario for the U.S., terminal oil depletion would be pushed back some years, but the end result is the same—terminal depletion.



World Crude Oil & Lease Condensate Production, including OPEC Core, to 2100 Ace. Theoildrum.com.

Alternative Energies

All alternative liquid energy sources combined could yield at most the equivalent of a few million barrels of oil per day. This supply would replace only a small fraction of declining global oil production, leaving a large and widening gap between increasing demand and declining production. There are insurmountable obstacles in ramping up oil production from coal gas-to-liquid (GTL), Canadian oil sands, and oil shale. First, developing substantial quantities oil from coal GTL and oil shale requires the consumption of enormous quantities of finite water resources that are dedicated by urban populations and agriculture in the western states. Second, the production of these three sources of energy damages the local environment and increases atmospheric CO_2 levels. Third, the capital costs for these ventures would be enormous, and increasing inflation (which is generated by high energy prices) will limit coal GTL and oil shale plant construction. Fourth, the high cost for imported oil will drain the financial resources needed for developing alternative liquid energies. For example, the concept of producing biodiesel from algae (also called oilgae, or algal biodiesel) shows some promise of providing limited amounts of liquid fuels (though there are major obstacles), but the billions (or trillions) of dollars of capital investment needed for large scale these ventures will be unobtainable in an era of high inflation, high capital costs, and high energy costs (oil and natural gas energy would be needed to build the infrastructure of these mega-projects).

The studies reviewed in this report indicate that alternatives will not provide significant amounts of liquid fuels. Thus it is not feasible to ramp up alternatives to replace oil, even if there are decades to prepare for the occurrence of Peak Oil. There are no viable mitigation options on the supply side regarding the Peak Oil crisis. Conservation should be pursued vigorously at levels of society.

Non-Fungibility of Energies

Efforts to manage the Peak Oil crisis will be limited by the difficulty in substituting one form of energy for another (without making expensive and lengthy modifications). Shortages of one type of energy cannot be filled by other types. Trucks and cars use only diesel or gasoline, not electricity or natural gas; residential and commercial buildings use only one source of energy for heating; and electric power can only be generated by the current use of either, coal, natural gas, or oil (without making costly alterations). When the nation experiences shortages of natural gas, oil cannot be substituted and vice versa. Without making costly modifications to buildings and improved generating and transportation capacity, electric power cannot replace oil and natural gas for heating homes, businesses, schools, and hospitals.

Solar power, nuclear energy, and coal are primarily useful for generating electric power, but these energies do not provide liquid fuels needed for transportation or mechanized agriculture, nor do they provide raw materials for manufacturing of 300,000 products, including fertilizer. Thus, an unlimited amount of electric power from solar, coal, nuclear fission, or nuclear fusion will not solve the nation's energy problems. After more than 100 years of research, the storage of electric energy remains an obstacle to the use of electric power in transportation. As the Union of Concerned Scientists indicates: "The future of battery-electric vehicles is somewhat cloudy at this time, but their development has already made important contributions to advancing electric drive-train and storage technologies needed by both hybrid and fuel cell vehicles. If further breakthroughs in battery technologies occur, BEVs could yet prove to be the future of clean transportation."

Interdependence in the Production of Energy

The production of each type of energy is highly dependent on other types of energy. Shortages or high energy prices for one type of energy will limit the production of other energies. Oil is critically important in the production of all forms of energy. Shortages in oil will mean shortages in gasoline, diesel, and jet fuel. Thus oil rig workers won't be able to travel to the oil fields and off-shore platforms; coal won't be mined or transported; electric power won't be generated in some plants; roads and bridges won't be maintained; and spare parts won't be delivered for oil drilling and refining, electric power generation, and for natural gas production. Shortages of natural gas will limit the generation of electric power and production of Canada's oil sands (unless equipment modifications are made so that the oil sands can be used to generate heat for processing of the oil sands).

Inflation and Scarce Capital

High energy costs will generate rising inflation in most sectors of the economy. As inflation and unemployment increase, individual investing will shrink, resulting in reduced capital formation. Scare capital will also result from the need to spend more and more national wealth on buying oil needed for food production, transportation, heating, and energy production. As the price of oil rises, the construction of nuclear power plants, coal GTL plants, and solar based alternative energy projects will become more and more costly. Individuals will lack resources for: building new homes close to agricultural production, buying energy efficient vehicles (especially because the trade-in values for low-gas-mileage-vehicles will plummet), and retrofitting homes with passive solar installations, insulated dormitories, or wood stoves.

Limits of Market Economies

Corporate enterprises exist mainly to make financial profits. Over last two and half centuries, abundant coal and oil energies bolstered expanding economies and corporate profits, and over the last century oil, natural gas, and technology explain the expansion of economies for the last century. Oil depletion and ever-deepening recession will erase profits and most corporations will fail.

In an era of high inflation and deepening depression, individual investors will lack funds for investing. In addition, investments in banks, equities, and bonds will shrink in value. Investments in banks, bonds, equities, and pension and retirement funds represent promises to provide future products and services that require oil, natural gas, and coal. As the cost of energy increases, the real value of these investments will decline. In a few years, such investments will lose value, and some years later they will be worthless. When investors and the public understand these realities, they will avoid investing in financial institutions. Chris Shaw is correct in writing that energy "is the one true currency" and "it always was and always will be."

Because of ever-worsening economic depression and rapidly rising energy costs, banks will hesitate in making loans for projects that have uncertain profitability due to high future energy costs. Such projects include: ultra deep water production of oil and natural gas; development of coal GTL; construction of nuclear power plants and wind turbines; relocation of populations from metropolitan areas to agricultural areas; and development of cargo rail, passenger rail, and public transportation.

Pervasive Ignorance about Energy

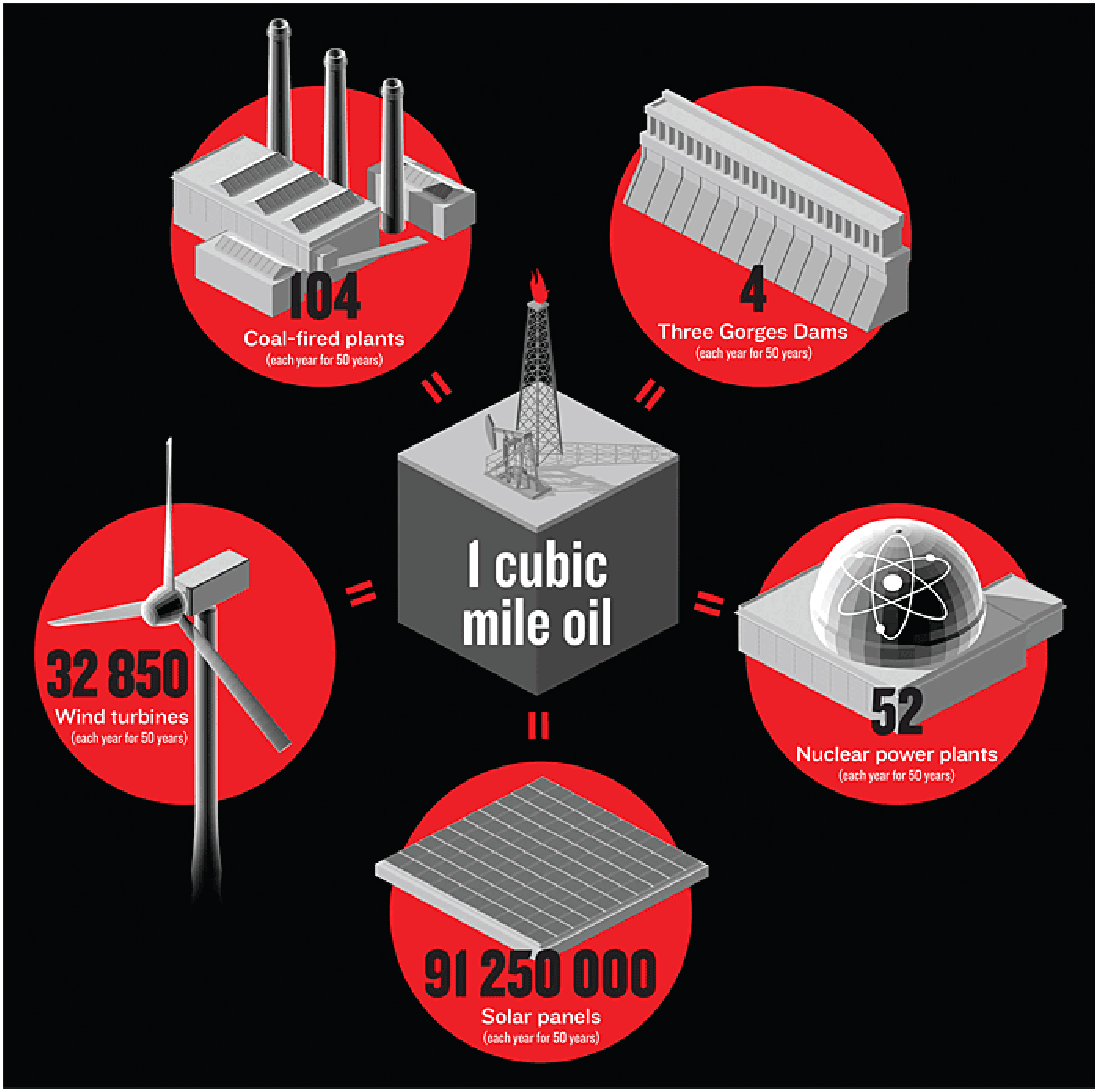
The public and leaders in business, industry, government, the media, and even some scientists in the energy field remain ignorant of many basics about energy and society. Very few leaders understand that energy is not just one of many issues, rather, energy is the paramount issue -- because energy under girds modern society. Because leaders lack a basic understanding of energy sources, the nation will continue to direct attention toward the hydrogen economy, corn ethanol, wind power, and solar energy -- even though the most authoritative sources conclude that these are not solutions for the liquid fuels problems facing the nation. Similarly, the media will continue to provide misinformation regarding "new discoveries," "new technologies" and "breakthroughs" (three examples: The New York Times, BusinessWeek, and BusinessWeek).

Some scientists in the energy field are not cognizant of the "limits to growth" studies (Mathews, Matthews and Randers) that predict global economic collapse following the depletion of fossil fuels. For the most part, scientists have assumed that energy problems could be solved. Professor Kenneth E. Boulding (a NAS study panelist) made the following critique of the 1977 National Academy of Science and National Academy of Engineering (NAS/NAE) study "Energy in Transition 1985-2010." (Page 617):

> "In preparing for the future, therefore, it is very important to have a wide range of options and to think in advance about how we are going to react to the worst cases as well as the best. The report does not quite do this. There is an underlying assumption throughout, for instance, that we will solve the problem of the development of large quantities of usable energy from constantly renewable sources, say, by 2010. Suppose, however, that in the next 50, 100, or 200 years we do not solve this problem; what then? It can hardly be doubted that there will be a deeply traumatic experience for the human race, which could well result in a catastrophe for which there is no historical parallel.
>
> It is a fundamental principle that we cannot discover what is not there. For nearly 100 years, for instance, there have been very high payoffs for the discovery of a cheap, light, and capacious battery for storing electricity on a large scale; we have completely failed to solve this problem. It is very hard to prove that something is impossible, but this failure at least suggests that the problem is difficult. The trouble with all permanent or long-lasting sources of energy, like the sun or the earth's internal heat, is that they are extremely diffuse and the cost of concentrating their energy may therefore be very high. Or with a bit of luck, it may not; we cannot be sure. To face a winding down of the extraordinary explosion of economic development that followed the rise of science and the discovery of fossil fuels would require extraordinary courage and sense of community on the part of the human race, which we could develop perhaps only under conditions of high perception of extreme challenge. I hope this may never have to take place, but it seems to me we cannot rule it out of our scenarios altogether."

This same critique applies to many current energy studies. Some scientists have forgotten several basic realities about energy. First, because energy can neither be created nor destroyed, energy cannot be invented. Second, energy must be consumed to produce energy. Third, a great deal of energy must be used to concentrate renewable energies, in particular solar energy directly from the sun's rays. Fourth, unlimited production of electric energy would not address the transportation and food production problems facing the U.S.

Fifth, other energies depend on oil for their production. Finally, the world is consuming enormous quantities of oil. Harry Goldstein and William Joules, BTUs, Quads – Let's Call the Whole Thing Off, Spectrum On Line, January 2007, Khebab, and others (Getting a Grasp on Oil Production Volumes, Theoildrum.com. October 9, 2007) show graphically how much oil is consumed globally (currently 1.02 cubic miles CMO of oil annually), and how this consumption compares to equivalents of several energy alternatives. Such analysis is useful for understanding the Herculean task of replacing oil with alternatives.



Source: See references in the paragraph above. Theoildrum.com. Permission to publish.

The Governmental Response

The federal government has not been planning for Peak Oil and its multiple impacts. The House of Representatives sponsors a Peak Oil Caucus, but only 15 of 435 representatives are Caucus members. The Caucus' most important accomplishments are education, requisitioning the GAO study of the government's response to Peak Oil, and recording congressional testimony of scientists who warn about Peak Oil. The government has no risk management plans for Peak Oil. The GAO study concluded:

> "Officials of key agencies we spoke with acknowledge that their efforts—with the exception of some studies—are not specifically designed to address peak oil. Federally sponsored studies we reviewed have expressed a growing concern over the potential for a peak and officials from key agencies have identified some options for addressing this issue. For example, DOE and USGS officials told us that developing better information about worldwide demand and supply and improving global estimates for non-conventional oil resources and oil in "frontier" regions that have yet to be fully explored could help prepare for a peak in oil production by reducing uncertainty about its timing. Agency officials also said that, in the event of an imminent peak, they could step up efforts to mitigate the consequences by, for example, further encouraging development and adoption of alternative fuels and advanced vehicle technologies. However, according to DOE, there is no formal strategy for coordinating and prioritizing federal efforts dealing with peak oil issues, either within DOE or between DOE and other key agencies."

The GAO recommended that the Department of Energy (a large bureaucracy that is a captive of the energy industry) study Peak Oil and develop a strategy to deal with it. The Peak Oil crisis, however, requires independent scientific analysis, as well as presidential and congressional leadership. The GAO should advise Congress, the President, and FEMA to prepare risk management strategies for Peak Oil impacts. Studies by the DOE, FEMA, NAS, GAO, and CBO should warn the nation about the imminent catastrophe. Instead, these agencies have done nothing, or they hinge hopes on alternative energies, or they see the catastrophe ahead but issue no clear warnings. No government agencies have studied how industry, business, government, and individuals will deal with the catastrophic of Peak Oil.

Federal, state, and local governments will do little to adopt policies to prepare for Peak Oil. Interest group pressures, constituency priorities, and political self-interest explain the political actions of most U.S. congressmen, state legislators, and local officials. Most government decisions will yield policies that interest groups and constituents favor, rather than rational and scientific policies that benefit the people. The general public and leaders in business, government, the media, and the academic community believe that the U.S. can discover more energy, or we can develop some alternative energy or technology, and maintain economic growth in the future. Most citizens and leaders believe deeply that solar energy, nuclear energy, hydrogen, biomass, ethanol, other renewables, or some invention will provide adequate energy for the economy. Deeply ingrained in the American psyche is the belief that we can accomplish almost anything if we apply technology and hard work to the task.

As the energy crisis deepens, all available energy will be consumed for survival -- food production, transportation of food and necessities, heating, and in handling emergencies. The national government, therefore, will not develop initiatives toward: relocation of the population to agricultural areas; local farming infrastructure based on animal and human labor; community farming and food preservation; freight and passenger rail systems; alternative programs for providing domestic potable water; passive solar installations; insulated dormitory rooms in homes; and provisions for residential waste disposal.

Quicksand Effect

Chris Shaw explains a “quicksand effect” for energy production: it takes energy to get energy, and because the highest quality oil is extracted first, high quality oil must be expended to extract oil that is of lower quality. And as depletion progresses, we must spend more and more energy to get less and less in return, until the difference between energy invested and energy returned is zero. To produce oil in the future, more and more oil must be consumed by constructing more and more oil rigs for drilling smaller and smaller oil pockets. For off-shore oil drilling, more and more rigs, platforms, ships, and pipelines must be constructed to extract oil from greater and greater depths. Matthew Simmons indicates that the replacement of aging oil rig, refinery, and pipeline equipment and infrastructure will cost a great deal in capital investments in the coming years. The manufacturing and transport of this equipment and infrastructure will use much oil. Canada’s oil sands are another case of the quicksand effect. In order to get 3 units of low quality oil energy, 2 units of high quality natural gas and oil are expended. The net energy gain is actually less when we count all of the energy costs for oil sands production: natural gas and oil for processing and refining; oil and natural gas used to manufacture trucks, processing equipment, pipelines, new houses, and airplanes (for transporting workers); and the energy used by trucks, processing equipment, airplanes, and pumps. In addition, oil sands operations contaminate local water supplies and generate much air pollution and carbon dioxide. Similarly, the GAO study found that "EOR [enhanced oil recovery] technologies [to extract additional oil from depleted oil fields] are much costlier than the conventional production methods used for the vast majority of oil produced," and "operating costs for deep water rigs are 3.0 to 4.5 times more than operating costs for typical shallow water rigs." The same concept applies to the use of high quality oil and natural gas energy to produce alternative sources of energy, such as corn ethanol, bio-diesel, wind turbines, and nuclear power plants.

Multiple Crises and a Grid Lock of Crises

Peak Oil means that the U.S. lacks the energy necessary to provide for transportation, food production, industry, manufacturing, residential heating, and the production of energy. Oil shortages and natural gas shortages will generate multiple crises for the nation: (1) Shortages in gasoline, diesel, and jet fuel will limit travel to work for oil rig/platform workers and technicians, coal miners, highway maintenance personnel, and maintenance workers for electric power generation stations and power lines. (2) Without truck and air transport, spare parts for virtually everything in the economy won't be delivered, including parts needed for highway maintenance and energy production equipment. Simmons notes that 50,000 unique parts are necessary to create a working oil field. Many more parts are necessary for ultra deep water drilling operations, including a variety of high tech ships, remotely operated underwater vehicles, seismic survey equipment, helicopters, and technologically complex platforms (see The New York Times and click on Multimedia Graphic). Thousands of corporations around the globe manufacture these parts, and many of these corporations will fail in the Peak Oil crisis. (3) States governments will lack funds for maintaining the Interstate Highway System, including snow plowing, bridge repair, surface repair, cleaning of culverts (necessary to avoid road washouts), and clearing of rock slides. A failure in one section of the Interstate highway will cut off transportation for that highway and everything it carries: food, emergency supplies, medicine, medical equipment, and spare parts necessary for energy production. (4) The power grid for all of North American will fail due to a lack of spare parts and maintenance for power lines and electric power generators, as well as from shortages in the supply of coal, natural gas, or oil used in generating electric power. Power failures could also result from the residential use of electric stoves and space heaters when there are shortages of oil and natural gas for home heating. This would overload the power grid, causing its failure. The nation depends on electric power for: industry; manufacturing; auto, truck, rail, and air transportation (electric motors pump diesel fuel, gasoline, and jet fuel); oil and natural gas heating systems; lighting; elevators; computers; broadcasting stations; radios; TVs; automated building systems; electric doors; telephone and cell phone services; water purification; water distribution; waste water treatment systems; government offices; hospitals; airports; and police and fire services, etc. Phillip Schewe, author of "The Grid: A Journey Through the Heart of Our Electrified World," writes that the nation's power infrastructure is "the most complex machine ever made." In "Lights Out: The Electricity Crisis, the Global Economy, and What It Means To You," author Jason Makansi emphasizes that "very few people on this planet truly appreciate how difficult it is to control the flow of electricity." A 2007 report of the North American Electric Reliability Corporation (NERC) concluded that peak power demand in the U.S. would increase 18% over the next decade and that planned new power supply sources would not meet that demand. NERC also noted concerns with natural gas disruptions and supplies, insufficient capacity for peak power demand during hot summers (due to air conditioning), incapacity in the transmission infrastructure, and a 40% loss of engineers and supervisors in 2009 due to retirements. According to Railton Frith and Paul H. Gilbert, power failures currently have the potential of paralyzing the nation for weeks or months. In an era of multiple crises and resource constraints, power failures will last longer and then become permanent. When power failures occur in winter, millions of people in the U.S. and Canada will die of exposure. There are not enough shelters for entire populations, and shelters will lack heat, adequate food and water, and sanitation. (4) Water purification and water distribution systems will fail, leaving millions of metropolitan residents without water. (5) Waste water treatment systems will fail, resulting in untreated sewage that will contaminate the drinking water for millions of residents who consume river water downstream. (6) Transportation and communications failures will cripple federal, state and local governments -- leaving and residents without emergency services, emergency shelters, police and fire protection, water supplies, and sanitation etc. (7) Mechanized farming will cease, and harvested crops won't be transported more than a few miles. (8) Food won't be transported from the Midwest, California, Florida, and Mexico to the U.S. population. (9) Fertilizer, pesticides, and herbicides won't be produced. (10) Due to limited farm acreage, most cities and towns will be unable to support their populations with sufficient food from local farming (see Paul Chefurka and Paul Chefurka). (10) Homes across the U.S. will lack heating. Even if homes are retrofitted with wood stoves, local biomass will be insufficient to provide for home heating, and it will not be possible to cut, split, and move wood in sufficient quantities.

In the coming years, the U.S. faces multiple energy crises. Each crisis will generate delays in handling other crises, thus making it more and more difficult to address multiplying problems. The worse things get, the worse they will get. A grid lock of crises will paralyze the nation.

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