Peak Oil – *Impacts on Commercial Aviation*

Conventional wisdom assumes a future with plentiful oil to satisfy the world's ever growing economies and higher living standards. However, all finite sources simply have limits to their growth and a global production peak is now imminent, followed by an irreversible decline. It is a problem that may soon eclipse global warming and deserves urgent attention by industry leaders and politicians if risks are to be fully understood and mitigation begun on a timely basis.

By Alex Kuhlman M.A.

The most important events in history, the ones that have the greatest impact on our lives, often slip by unnoticed at the time. Today, the most pivotal challenge facing our modern industrial society is that the resource upon which our lives have been built is becoming less plentiful. Global oil production is approaching an all-time peak before going into an irreversible and permanent decline, which will change the world as we know it. This is not a conspiracy theory, but rather the scientific conclusion of the world's most widely-respected geologists, physicists, and investment bankers. The only uncertainty is when it will happen. Even amongst the most optimistic experts the consensus is that the tipping point and the risk of a permanent crisis will occur before the end of the next decade, while many industry analysts predict a global peak is imminent.

In a world that is dependent on oil and gas for almost everything we do, burning over 155.000 liters per second [1], with global economies geared almost inextricably to infinite supplies of cheap oil, the implications of having less oil tomorrow than today are far-reaching. But there is enormous psychological resistance to this reality, and politicians and experts have no 'plan B' to fall back onto. It will be a daunting task—requiring decades of preparation—to successfully transition to a post-oil era and mitigate the effects on the airline industry and our society.

Peak Oil

The world is not running out of oil itself. Our industrial civilization has consumed approximately half of the world's total reserve of about 2.5 trillion barrels of conventional oil. The problem is that the rate at which oil producers can extract oil is slowly reaching the maximum level possible. With great effort and expenditure, production rates can possibly be maintained for a few more years. But beyond that, global oil production must decline, and nothing in science, technology, or engineering can prevent it. This follows from geologist Dr King Hubbert's well-established theory that the output of individual oil wells follows a bell-shaped curve. Production rises after discovery, reaches a peak and then declines. This production peak typically occurs after roughly half of the oil in a reservoir has been recovered. So as a field ages past the midpoint of its life, it becomes more difficult to maintain its production rate with geology placing an upper limit on price-dependent reserves growth. This principle holds on a world scale, because global production is the cumulative total of production of individual wells, fields, and regions. On this basis, Dr Hubbert correctly predicted the peaking of US oil production that occurred around 1970, which has been in steady decline since [2]. Global oil discoveries peaked in 1964 and have been declining ever since, despite improved technologies [3]. More than 95 percent of all recoverable oil has now been found, and approximately 90 percent of all known reserves are currently in production [4]. There have been no significant discoveries of new oil since 2003. Given geologists' sophisticated understanding of the characteristics that would indicate a major oil field, it is highly unlikely that any potentially meaningful area has eluded their attention. To put the size of the much debated Alaska National Wildlife Refuge (ANWR) into perspective, it will take ten years after opening to reach the maximum production rate of approximately just 1 million barrels per day [2]. This quantity can satisfy only 1 percent of current global daily consumption, and by 2025 it will represent only 0.5 percent, which underscores just how serious the human predicament has become. Oil is now being consumed almost four times faster than it is being discovered, and the situation is becoming critical. More recently, prominent organizations such as the Royal Swedish Academy of Sciences [5], corporations, chief economists, and numerous petroleum scientists and oil industry analysts have all raised serious concerns. Even Chevron has publicly admitted that the age of cheap oil is over and that production in 33 out of 48 nations has gone into permanent decline. It was a shocking revelation at the end of 2005, when the Kuwait Oil admitted that its Burgan field, the second largest oil field in the world, is exhausted and is past its peak output [6]. All finite sources simply have their limits to growth and will sooner or later fail to keep up with exponential demand growth.

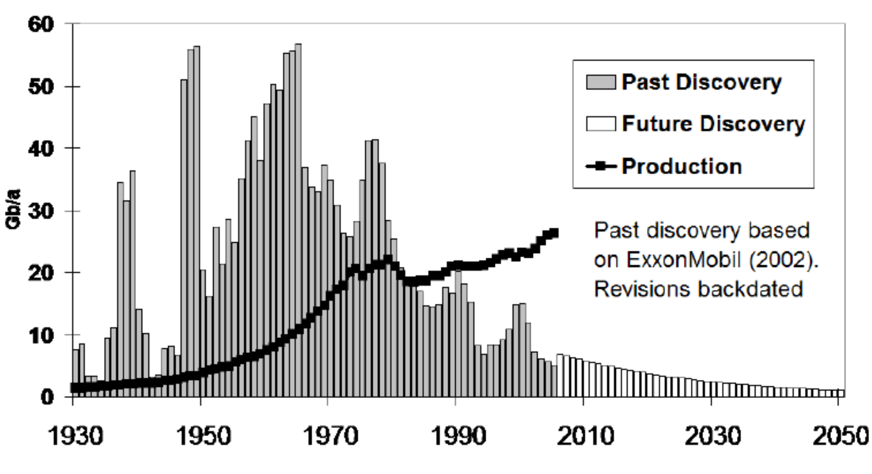
Geologist Matthew Simmons has predicted that the world's largest producer, Saudi Arabia, will soon reach a peak, confronting the world with a catastrophic oil shortage. Based on hundreds of technical papers from the national oil company Aramco, he concludes that the kingdom's entire oil system is old and frayed, with reserves deliberately overestimated [7]. For many years, the Saudis have injected enormous amounts of seawater into the Ghawar field — the world's largest — to maintain high pressure inside. These methods have only temporary effects, and will eventually lead to accelerated rates of depletion in the future. It is a myth that the technical revolution, which means the use of improved recovery methods, increases reserves. Modern production aims to get maximum production to get maximum profit, without any concern for the need to formulate a plan for the long term. With Saudi Arabia relying on only five mega-fields for 90 percent of its total output, providing 73 percent of all incremental world demand, these facts are far from reassuring. OPEC's recent reluctance to increase output and boost investments as oil prices are approaching the $80 mark may be an indication of inability rather than choice.

The Fallacy of Alternatives

Oil allows us to operate highly complex systems at gigantic scales. Its physical and chemical versatility, combined with its high energy-density, are such that there is no readily available alternative energy source that can replace oil as it steadily declines over future decades. Development and implementation of a viable alternative would take many decades of intensive preparation and effort. Alternatives such as wind, waves, and other renewable energy sources are all marginal. They require massive amounts of oil and other scarce resources to locate and mine the raw materials necessary—some of which are already in permanent states of scarcity—to build them, and even more oil to distribute them, maintain them, and to adapt current infrastructure to run on them. Ethanol has a net energy value of around zero or less and requires vast amounts of land area, substituting food security for the illusion of energy security [7]. Hydrogen is an energy carrier rather than a source, requiring much more energy input that output (a so-called 'energy sink'). Nuclear power plants require almost a decade and huge sums of money to construct, while uranium will soon face some very serious global shortages with uranium prices already having almost doubled in the last year [9]. The tar sands in Canada have absolute production limits—calculated at 3.5 percent of total current oil production until 2025—whilst requiring large inputs from other finite sources, such as natural gas and water, leaving behind toxic tales of waste and increasing carbon emissions even further [10]. The less-known oil shale deposits may become just about viable, but their potential production contribution would be negligible.

Conventional wisdom assumes that oil depletion is a straightforward engineering problem, but human ingenuity is unlikely to overcome nature's limiting factors. Although there are many technologically viable alternatives to oil, none have the capability of being scaled up in such quantities. They are certainly worthy investments on a household or village scale, but to hope that they are going to power our ever-growing global industrial economy within our generation—or even a fraction of it—is simply unrealistic. In a recent interview with The Times, Shell CEO Jeroen van der Veer calls for a "reality check" and warns that the world's energy crisis cannot be solved by renewables. "Contrary to public perceptions, renewable energy is not the silver bullet that will soon solve all our problems. Just when energy demand is surging, many of the world's conventional oil fields are going into decline. The world is blinding itself to the reality of its energy problems, ignoring the scale of growth in demand from developing countries and placing too much faith in renewable sources of power", according to van der Veer.[16]

Figure 1: *The growing gap - Regular conventional Oil. Source: C.J.Campbell*



Impacts on Aviation: Short-Term

Oil provides 40 percent of all primary energy, and more than 90 percent of energy for our transport systems. In the USA, the airline industry is the fourth largest consumer of oil, representing a modest 6 percent of total domestic consumption [11]. The cost of jet fuel has more than doubled since the beginning of 2004, and, for many airlines, is now overtaking labor as the greatest operating expense. IATA has predicted a $9 billion impact on airlines' 2007 fuel bill because of higher prices. Only a few carriers, like Southwest Airlines, had the foresight, courage, and resources to buy hedging contracts to fix their fuel price with forward contracts for a large proportion of their requirements. Some other major airlines have hedged only a small proportion of their fuel requirements, while the remainder is fully exposed to future price rises.

Impacts on Aviation: Medium-Term

The worlds of economics and business still routinely assume a future with cheap oil that is in growing supply. At the time of writing, oil futures as far away as 2012 are still trading around the $70 per barrel mark, while investment bank Goldman Sachs predicts that after a temporary 'super spike', prices will return to the $30-$50 bracket after 2009.

In other words, peak oil is still invisible to Wall Street for a variety of reasons. Once financial analysts recognize our predicament en masse, there could be a collapse of confidence, possibly leading to widespread market-based panic, and to oil prices quickly crossing the $100 barrier, further hurting the airline industry in the process. In addition, high energy prices combined with higher interest rates to subdue inflation will decrease consumers' disposable income and dampen demand—the last five recessions in the USA were all preceded by a rise in the price of oil. As a result, the number of cash-strapped airlines will increase, while weaker airlines without hedging contracts possibly face collapse. The only way oil prices will not top triple-digit figures within the next few years is if there is a huge worldwide depression. This effect would only be temporary and limited (the price elasticity of oil is low), but equally damaging to the airline industry. Most likely, the more successful airlines will be flag carriers from OPEC nations in the Middle East as this region will benefit from higher oil prices, allowing these airlines to go from strength to strength. For example, Emirates have already ordered 43 Airbus A380s, which is a key element in the company's future growth. An advantage of the A380 will be its lower fuel burn per seat mile. The new Boeing 787, which is 25 percent more fuel-efficient, could also play an important role in mitigating the effect of higher oil prices in the medium-term.

Impacts on Aviation: Long-Term

The future outlook for commercial aviation is dim. If oil prices continue to rise further, the world economy will be confronted with a major shock that will stunt economic growth and increase inflation. During the transition period to a post-oil era, insufficient affordable oil supplies will be available to fuel today's transport systems, and there may be massive disruptions as the global decline of oil is accelerated. There may be social unrest, food shortages (consider that agriculture accounts for 17 percent of the US annual energy budget [12] and that it currently takes 10 calories of fossil fuel to produce 1 calorie of food in the USA [13]), a strong reduction of business and government activity, and very serious unemployment. Even if the airline industry can successfully source and adapt to substitute fuels, a large proportion of the demand for air travel could be almost completely destroyed. Once again, air travel may become the prerogative again of the wealthy and government business, and the world will become a large place again. Admittedly, it is difficult to envision a future that is so drastically dislocated from the present.

Global Challenges

The 1973 oil crisis was caused by only a 9 percent drop in world oil supplies, but brought widespread panic and should have been a wake-up call for the world. Former President Jimmy Carter had the vision and the courage to tell the US public about the changes needed, because the continued ultra-dependence on oil was a dangerous trap [14]. In 2005, a report was prepared for the US Department of Energy by a team led by Robert Hirsch, who has a distinguished background in the oil industry and is a senior energy analyst. He concluded: "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. Mitigation will require a minimum of a decade of intense, expensive effort, because the scale of liquid fuels mitigation is inherently extremely large. Intervention by governments will be required, because the economic and social implications of oil peaking would otherwise be chaotic" [11]. The conclusion of the Hirsch report raises the following challenges:

Awareness

The odds of successfully drafting and implementing a plan B, within the small and narrowing 'window of opportunity' are unfortunately stacked high against us. Awareness is increasing, but peak oil has not yet penetrated a large part of global consciousness. We have allowed ourselves to become hard-wired to the oil economy. It is what some call an 'outside context problem'; it is so far from our normal realm of experience that we are collectively having a difficult time accepting and processing it. With a global crisis imminent and the long lead times required, the world must emerge from denial without further delay.

Expenditure and Effort

The world would require enormous effort and expenditure in current energy infrastructure to slow the decline and buy more time. A smooth and sustainable transition to a post-oil era still requires an abundant fossil fuel platform from which to work. The International Energy Agency (IEA) has noted the necessity for an astronomical $17 trillion merely to maintain sufficiency for the next one or two decades [15]. To put this into context, that is almost twice the national debt of the USA—just to keep things ticking along. This figure does not even take into account the much lower-than-anticipated maximum possible rate of production from Saudi Arabia. In addition to this expense, there is the major obstacle of the huge and unprecedented cost and effort involved in re-engineering the estimated $45 trillion global infrastructure that was based on consistently low oil prices. For example, there will be enormous challenges and cost associated with replacement of a global fleet of aircraft—with a current median lifespan of around 22 years—to make way for non-conventional types that do not rely on vast quantities of conventional fossil fuels.

New Economic Models

The most basic assumption of our future economic well-being is fundamentally flawed—which is why government intervention is required. Our economic systems are based on growth and this can, by definition, not go on forever when it relies on limited physical resources. On current

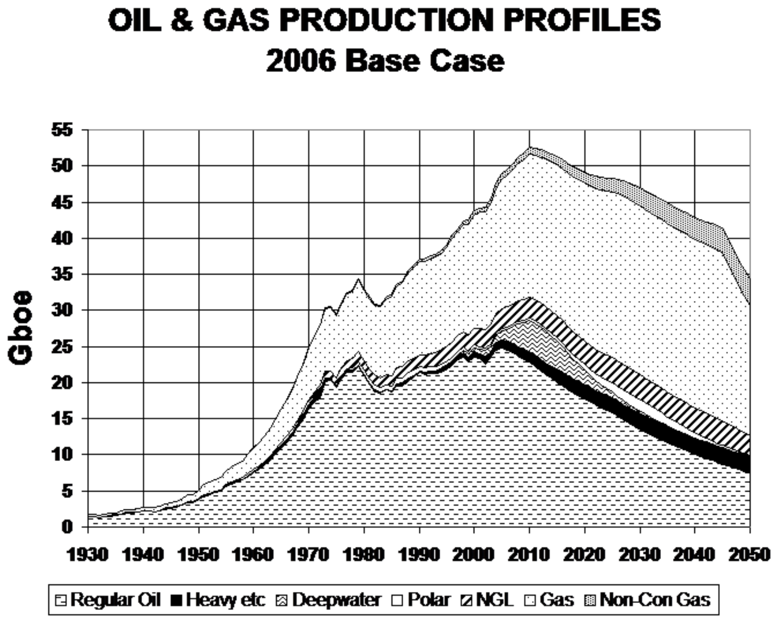


Figure 2: *Oil and gas liquids 2005 scenario. Source: Association for the Study of Peak Oil and Gas (ASPO)*

trends (10 percent annual growth), a country like China will require the same amount of oil by 2031 that the world currently uses (84m barrels/day).[1] Clearly, China cannot continue its present course for two or three more decades whilst facing energy starvation along with the rest of the world. To further illustrate modern society's insane requirements for oil and other scarce resources, the United Nations University has calculated that the construction of an average computer and monitor requires at least 530lb (240kg) of fossil fuel, 50lb (22kg) of chemicals, and 3,300lb (1,500kg) of water—or a total of nearly 4,000lb (1.8t), equivalent to the weight of a rhinoceros. Likewise, the production process for an average-size car uses at least 27 barrels (1,150USg) of oil, translating to vast amounts to replace the majority of 700 million motor vehicles around the globe with yet-to-be developed alternatives. Today's market mechanisms are incapable of taking into account the long lead times and resources required to balance supply and demand, and ultimately replace fossil fuels. Traditional economics also ignore the EROI (Energy Return on Investment) or net energy limitations. When oil production first began in the mid-19th century, the largest oil fields recovered up to 50-100 barrels of oil for every barrel used in the extraction, transport, and refining. This ratio becomes increasingly inefficient as oil fields mature, and is currently around 30. But the ratio for non-conventional oils, such as the Canadian oil sands, is approximately 3:1, which is very poor from an energy economics viewpoint. Those who assure us that there is plenty of oil left below the surface are correct—but they fail to understand the concept of peak oil and net energy. There will always be large deposits of oil that would demand equal or more energy to extract than they would liberate, regardless of the market price. In addition, non-conventional sources have the additional limitation of absolute maximum daily production rates.

Political Pressure

Consuming nations must understand the gravity of the situation and reform. They will need to put in place radical and extremely tough policies to curb oil demand growth. However, most governments' planning horizon is far too limited, with fear of voters' reactions too great to seriously address the problem. People generally tend to take to the streets in protest because they want to consume more, not less. Cynicism and pure denial are more common responses than acceptance and activism.

Mitigation Strategies

The outlook is far from reassuring. Next-generation sustainable alternatives are still in the realms of science fiction; and the potential contribution of available or near-available options for increasing world energy supplies are marginal and will require 10 to 20 years of accelerated effort. If, against all odds, the global peak does not occur for another few decades, there would still be time—in theory. Any remedies would be highly complex and command vast resources and sacrifices. However, the social and economic cost of inaction would far outweigh those of any mitigation strategies. We need to realign our thinking and require an immediate reassessment of reality and an orchestrated effort and intervention by government from around the world on a scale not seen before in human history. A new path must be chosen to conserve the underlying fossil fuel base required to develop and implement sustainable energy sources capable of running even a substantial fraction of countries such as the USA. Otherwise, we may simply lack the tools to move forward to replace a fluid so cheap, abundant, and versatile.

Airline Industry Challenges

Peak oil does not mean that everything will suddenly come to an end. The shortage of oil will gradually increase over time, as extraction from wells is unable to meet global demand. Although airlines worldwide consume only around 2 percent of total consumption, they will continue to compete for the same scarce resource along with all other users around the world. To alleviate the effects in the short-term, hedging has become a crucial part of business for the most successful airlines [17]. Increasing fuel efficiency and controlling other costs are also vital for survival, but in isolation will be neither sufficient nor timely enough to solve the problem.

New Strategies

Airlines must broaden their horizons and adopt new strategies in the medium-term. They will have to find new ways to work together, and venture down previously uncharted paths. The flight paths that airlines have thus far followed will no longer be valid, and only those carriers that are able to successfully change their business models will fly on, at least for a while. This may involve strategic diversifications, such as Richard Branson's plans to build a $2 billion

Virgin oil refinery —which will take half a decade to complete—and his suggestion to take the Virgin group into the field of oil exploration. Airbus now delivers more passenger aircraft than Boeing, but in recognition of the pending decline in air travel Boeing has already diversified into defense, space, and communications, avoiding the consequences of overproduction in its traditional line of business.

Bio-Fuels

Branson also recently revealed a $400 million plan to venture into renewable fuels that could ultimately replace jet fuel, and is lobbying air regulators to use up to 5 percent bio-fuel blends to power an unmodified Virgin fleet. One of the big advantages of bio-fuels is that it can use the current fuel distribution infrastructure. These renewable fuels can be made from corn, soya, algae, or Jatropha plants. One of the problems with mass-producing bio-fuels from conventional crops is that it competes with food crops for arable land. In addition, the majority of feedstock requires large quantities of fossil fuel inputs and hence their net energy is poor compared to fossil fuels. As far as the suitability for use of bio-fuels in turbine engines, researchers from the University of North Dakota have recently successfully developed a new batch of fuel from crop oils with a lower freezing point, which had thus far been a major obstacle. There are also environmental benefits, but despite near-readiness for testing by the US Air Force, development and the lengthy process of certification are still in preliminary stages. Synthetic fuels have the potential to replace a substantial fraction of fuel for the aviation industry, but not on the scale required for other modes of transport. Even if airlines manage to achieve a high degree of autonomy by taking control of their energy source, they cannot operate and function in isolation. As a whole, the airline industry will continue to rely on the vast surrounding fossil fuel-intensive infrastructure for support. Furthermore, without continued economic prosperity and stability, people may no longer have the cash to travel, shaking the very foundations of the airlines' raison d'être. Nevertheless, as liquid fuel prices continue to rise, it would make a lot of sense for an airline to aggressively expand its interests into the sectors of alternative energy and conventional energy, allowing airlines to cross-subsidize and protect their core business in the near-term as part of a very comprehensive hedging strategy.

The End of the Oil Party?

Famous psychologist Carl Jung once noted: "People cannot stand too much reality." With oil production declining in almost every nation outside the Middle East, and spare capacity already quickly disappearing throughout the system, the phenomenon of peak oil itself and a pending decline is almost self-evident and hardly needs defending. While the potential apocalyptic implications are far more difficult to digest, they cannot be just wished away. The inescapable conclusion is that the scale and complexity of the problems that must be resolved to avert a permanent crisis are enormous and almost inconceivable. More than a decade will be required, under the most favorable circumstances, for the collective contributions of substitutes to produce meaningful results. Optimists may argue that technology, the market, brilliant scientists, and comprehensive government programs are going to hold things together. However, with an acute lack of awareness, time, knowledge, capital, energy, political will and international collaboration, it is difficult to see how business can continue as usual. This is a startling conclusion, but it would be the most logical outcome of a process that has been building for decades. Meanwhile, the aviation industry should prepare itself for an orderly and profitable demise of the great aviation adventure.

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