The Oil Crisis and its Impact on the Air Cargo Industry

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Introduction

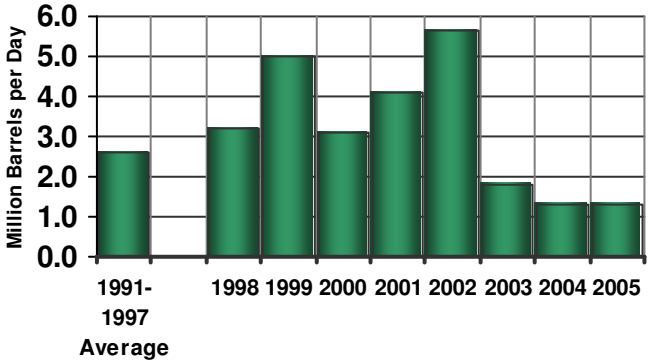
The first five years of the 21st century have brought a great deal of turmoil and instability to the global oil market. In November 2001, oil prices stood at under $20 a barrel. By April 2006, they crossed the $75 mark. Many reasons brought to the steep rise in oil prices among them growing demand in developing Asia, the collapse of major Russian oil company Yukos, lack of sufficient investment, terrorism and political instability in several oil producing countries, fear of military confrontation with Iran and increased hurricane activity in the U.S. This sudden rise in oil prices has already taken a toll on the global economy. The International Monetary Fund suggests that the recent oil price increases were the primary factor behind the decline of global GDP growth by 0.7–0.8 percentage points in 2005–06 relative to 2004. While oil prices impact global economy at large they impose a particular burden on energy intensive industries like the transportation and petrochemical industries. The big question is whether the oil market is suffering a temporary disruption or whether we are at the outset of a new era in which oil output is nearing its peak and will no longer be sufficient to meet global demand. Are we in a midst of a spike or are we on the brink of a new plateau?

Pessimists argue there's simply not enough oil to meet the booming demands coming from developing countries like China and India and still satisfy the voracious appetites of traditional consumers in the industrialized world. Such voices also come from within the petroleum industry. Venezuela's energy minister Rafael Ramirez remarked in 2004 that "the history of cheap oil may have ended." Around the same time, Chevron's CEO admitted that "the era of easy oil is over."[1] Governmental and multinational organizations tasked with projecting energy prices are also showing signs of pessimism. In its *World Energy Outlook through 2030* the International Energy Agency, raised its long-term forecast for oil prices by as much as one-third and painted a pessimistic picture of the future economy if the industrialized world does not begin to wean itself off oil.[2] The Energy Information Administration of the U.S. Department of Energy came to similar conclusions. It projects that oil prices will remain well above $50 a barrel for the next 25 years. This is a sharp shift from its 2005 projection that real oil prices will decline to $31 a barrel by 2025. The reason for the shift is a growing realization that OPEC oil producers are not likely to pump as much as oil as previously projected to meet growing demand. There are those who see an even bleaker future. Goldman Sachs Group predicts that the decline in supply of cheap oil will bring crude prices to $105 a barrel by the end of the decade.[3] Some analysts such as Matthew Simmons, former energy advisor to President George W. Bush, predict oil prices of between $200 and $250 a barrel in the coming years.[4] Optimists, on the other hand, point out that some experts have been predicting a scarcity of oil for nearly a century -- and yet the oil keeps

[1] Chevron Corporation website, http://www.willyoujoinus.com/downloads/manifesto.pdf
[2] International Energy Agency, *World Energy Outlook 2005*.
[3] "Goldman's Murti Says `Peak Oil' Risks Sending Prices Above $105," *Bloomberg*, December 19, 2005.
[4] "Olpreis kann auf 200 bis 250 Dollar steigen," *Capital*, January 5, 2006.

coming. They hold that the combination of today's high oil prices and improved extraction techniques means that the break-even point for exploiting harder to extract oil is getting ever closer. Saudi Arabian Oil Minister Ali al-Naimi and Exxon Mobil Corp. President Rex Tillerson say oil supplies will last for decades and significant decline in prices is projected. In its June 2005 study, Cambridge Energy Research Associates (CERA) projected that significant oil supply capacity of as much as 16 million barrels per day (mbd) will be coming on stream by the end of the decade. The report also projects that unconventional oil will play a much larger role in the growth of supply than is currently believed, reaching almost 35% of supply.[5] Optimist assume that all this anticipated extra supply will drive oil prices back to the mid-$30s.

It is difficult to determine who is right. Forecasting future oil prices has always been a tough challenge. The reason is that most of the world's oil reserves are concentrated in the hands of governments which provide very little access to their field by field reserve data and, even worse, resist privatization of their oil industry and foreign investment in their countries. We are also unable to predict with certainty what will be the impact of geological depletion on the oil market and how far we are from peak oil, the point in which half of the world's cheaply recoverable oil has been depleted and from where price never goes down.
One thing both pessimists and optimists agree on is that the coming years will bring significant price instability, stemming from the fact that the market lacks sufficient liquidity. Until 2003 the global oil market enjoyed a large amount of spare production capacity: the ability of some producers, primarily Saudi Arabia, to inject extra oil into the market in the event of supply disruption. Due to growth in demand in developing Asia this spare capacity has been eroded from about 5.5mbd in 2002 to less than one million barrels per day today. Little spare capacity means the full burden of sudden shortages or supply disruptions is reflected in current spot prices. Every drop in production can cause a sharp price spike. Insufficient spare capacity also creates a premium of its own for the forward barrel, based on concerns with what could happen in an event of a disruption. Since no major oil producing nation is likely to invest billions of dollars in equipment that lies idle most of the time lack of spare production capacity will continue to haunt the market for many years to come.



Spare production capacity is declining

[5] *Worldwide Liquids Capacity Outlook to 2010 – Tight Supply or Excess of Riches*, Cambridge Energy Research Associates, June 2005.

No doubt increasing oil prices are likely to dampen global trade. By value, 40 percent of goods traded internationally are transported as air cargo; cargo traffic is a leading indicator of any economic slowdown. The air cargo industry itself, in which fuel accounts for 20-30% of the operational cost, is poised to be the prime casualty of the new era of expensive oil. Jet fuel prices have almost tripled in the past four years. As a result, the world's airlines and cargo carriers spent over $100 billion on fuel in 2005, a 50% increase over 2004, according to the IATA.[6] At reasonable oil prices of $30-$40 a barrel, world air cargo traffic was projected to expand at an average annual rate of 6.2% for the next two decades, tripling over current traffic levels.[7] But the recent spike in oil prices is taking the air cargo industry into uncharted territory, raising questions about the economic viability of many players in the industry. Skyrocketing fuel prices have already brought airlines to suspend flights and discontinue services. Some carriers like United Airlines, Delta and Northwest, have declared bankruptcy.

This paper will attempt to provide the medium- and long-term outlook for the oil market, and to present the relevant risk factors on the demand and supply sides. It will discuss the potential policy and technological solutions consumers can adopt to reduce their vulnerability to price shocks and declining supply. Finally, it will discuss the potential pathways available to the air cargo industry in order for it to maintain its financial viability in the face of oil market volatility.

Problems facing the global oil industry

Growing demand

The main consumers of oil will continue to be the advanced economies; the U.S., OECD Europe, and Japan together consume about half of global annual oil output. But during the course of the coming two decades, the developing Asian countries are projected to grow at a rate several times faster than those of the industrialized world. China's GDP growth is expected to grow at nearly 6% per year, compared with 1.7% for Japan, 2.2% for Europe, and 2.9% for North America.[8] When it comes to oil, rapid economic growth in China and India, together a third of humanity, has caused in recent years what can be viewed as a demand shock. China's automobile market demonstrates the degree of the challenge humanity is facing. In 1994, there were 9.4 million vehicles on the road in China. In 2004, there were 28 million vehicles. In 2020, the Chinese government predicts, there will be 140 million. Barring a policy shift, most of these cars will operate primarily on petroleum products. As a result of its growth, China became in 1993 a net oil importer and since then its oil consumption has

[6] "European, Asian Carriers Cope Better With Soaring Fuel Costs," *Aviation Week & Space Technology*, October 9, 2005.
[7] Boeing, *World Air Cargo Forecast 2004/2005*.
[8] *World Economic Outlook*, International Monetary Fund, April 2005.

grown by leaps and bounds. China recently surpassed Japan as the No. 2 oil consumer behind the U.S. Its demand for oil is projected to grow at a rate of 500,000 barrels per year in comparison to U.S. demand growth of approximately 200,000 barrels per year. Altogether, according to the reference case of the *International Energy Outlook 2005* of the U.S. Department of Energy, world demand for crude oil will grow from 85 million barrels per day today to 103 million barrels per day in 2015 and to just over 119 million barrels per day in 2025. But oil demand will be mostly a factor of price. Though demand in recent years has been fairly unresponsive to price changes—a 10 percent a barrel increase in prices reduces demand by only about 1 percent—large price changes, such as the ones experienced in the 1970s, could have substantial impact on it. Such spikes could trigger a significant adjustment of technology and oil consumption, bringing governments to introduce price controls and other austerity measures. If such disruptions occur, growth in demand could be dampened to 91 mbd by 2015 and 103 mbd by 2025.[9] Demand for oil could also be affected by unexpected catastrophes like natural disasters or an outbreak of flu pandemic. Such events could slow global economic activity, bringing to a sharp downturn in demand for oil.

Constrained supply

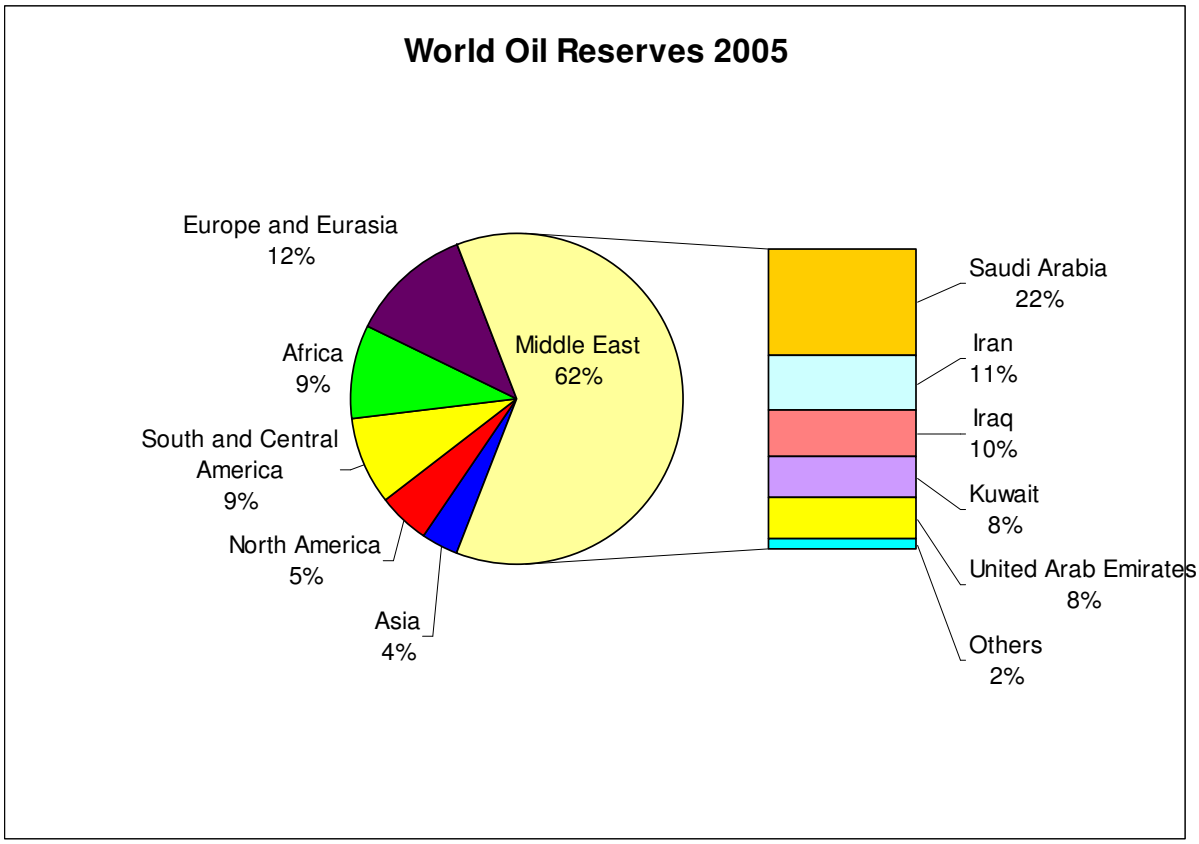
The projected increase in world oil demand would require in the next 25 years an increment to world production capability of close to 40 mbd relative to today's level. This figure only represents the net addition. The gross addition will have to be far higher as it includes the need to replace depleted oil which today stands on 5%. To meet 2010 requirements of some 94 mbd entails a net new capacity of 8mbd plus replaced depletion of 22mbd. This adds up to a total of 30mbd of new oil not currently available, equivalent to the total amount of oil currently produced by OPEC. Will the industry be able to ramp up production to such level? In 2005 rapid depletion in North Sea, slowdown in Russia's production, delays in the Caspian, hurricanes in Gulf of Mexico led to a total of net new additions of under 300,000 barrels. If one is to judge by last year's performance the answer is likely to be negative.

Depletion today is dramatically impacting the performance of all major oil producing countries. The North Sea's output went down from 6.4mbd in 2000 to under 2.1mbd in 2005, turning the United Kingdom from an oil exporter to a net importer. Venezuela has been losing output since 2002. Indonesia recently turned from an exporter into a net importer. Iran's decline rate stands at 9% per year. In the U.S., production has been sliding for a third consecutive decade. This decline is going to worsen due to the onset of a 10-20 year cycle of increased hurricane activity in the Gulf of Mexico, home to almost half of U.S. domestic production.

All this begs for a rapid increase in new supply. In the past decade non-OPEC suppliers, despite the fact they account for under a third of the world total

[9] *International Energy Outlook 2005.*

reserves, provided additional supply far above their relative share. They were able to do so primarily because they pump at an unregulated pace and are not subject to production quotas. But it is not clear whether non-OPEC production is sustainable. Exploration, development, and production costs in non-OPEC countries are much higher than in OPEC countries and the reserve-to-production ratio -- an indicator of how long proven reserves would last at current production rates -- is far smaller than OPEC's. Exxon Mobil Corporation has estimated that non-OPEC production--this includes Russia and West Africa--will peak within a decade.[10] At that point, there will be little easily recoverable oil left outside of the Middle East. This means that over the next two decades the call on OPEC will be significant, requiring that it more than double its output. It is very unlikely that OPEC members would be able to step to the plate with such huge quantities of oil. The Saudis claim they could raise output from 9.5mbd today to 12.5mbd by 2009 and to this end they are planning to increase the number of their drilling rigs from 55 in 2004 to 110 in 2006 but it is not clear how successful they will be in sustaining such level of production.



Iraq, OPEC's second largest reserve, remains a wild card. Prior to the U.S. invasion it was believed that the country could quickly ramp up production and exceed its pre-1990 war level of 3.5mbd by 2004. But due to a sustained campaign of sabotage Iraqi production has actually declined to 2.1mbd and oil companies are reluctant to invest in the country. Unless security is restored the

[10] Exxon president predicts non-OPEC peak in 10 years, *Oil and Gas Journal*, Dec 13, 2004.

country is not likely to become a major producer. The future of Iran, OPEC's third largest reserve, is also in question. The country's aspirations to develop nuclear weapons could soon put it under international sanctions which would, in turn affect its oil production and the ability of international oil companies to invest there. Another important OPEC member, Nigeria, has become increasingly volatile in recent years and oil companies are reluctant to take the risks it presents. In February 2006, rebels who want greater control of the oil wealth produced on their land declared a "total war" against all foreign oil interests in the Niger Delta.

Three major factors will determine whether OPEC and non OPEC countries will have the ability to satisfy the world's thirst for oil in the coming years.

1. Availability of investment opportunities

Low oil prices in the 1980s and 1990s brought to underinvestment in the oil industry and over reliance on the surplus capacity that was created in the 1970s. Now with strong demand, governments, national oil companies as well as international oil and gas companies all face the challenge of formulating and implementing viable investment programs to replace depleted reserves and develop their upstream sector. There is also an immediate need for new pipeline infrastructure and more tankers to transport crude to the world markets and an even more urgent need for increased refining capacity to convert crude into various petroleum products. Shortages of skilled workers and providers of oil services also pose a problem.

More troubling is the fact that OPEC producers present significant political hurdles, tight restrictions and other legal constraints to foreign investors. As a result, little investment is made in the places where most of the reserves are concentrated. For example, only 5% of ExxonMobil's investments 2001-2005 were in the Middle East, home of two thirds of the world's oil reserves. In major oil producing countries like Iraq, Iran, and until recently Libya, it was sanctions that have kept international oil companies from investing. The Russian government's break-up of Yukos has raised the risk of expropriation for foreign companies operating in that country. Such limitations have caused delays in the development of these countries' petroleum industry which could create acute shortages in the future. It takes about 8-10 years from the beginning of a drilling prospect until the oil reaches a pipeline from which it can move into the world market. This means that every delay in the development of new fields will translate into higher oil prices.

According to the IEA, if producers in the Middle East and North Africa do not immediately increase investment substantially, the average price of crude oil imported by IEA members would be unlikely to fall at all by 2010 from current high levels, and would rise to an assumed price of $86 a barrel in nominal terms by 2030. On the other hand, if these regions begin investing, prices could

average $65 a barrel in 2030. To meet rising world demand, oil and gas producers need to raise their average annual investment to $200 billion from now until 2030. Middle East producers currently invest about $15 billion annually.

2. Terrorism and political instability

It is a sad fact that most of the oil producing countries suffer from social and economic illnesses which make them particularly prone to conflict and political instability. Rapid populations growth, "youth bulges," unemployment, democracy deficit and failure of regimes to diversify their economies have created severe strain in important oil producing countries like Saudi Arabia, Iran, Iraq and Nigeria. These strains are likely to deepen over time, creating an inhospitable investment climate in these countries. In addition, oil companies face growing security risks as they move into more unstable parts of the world in search of new oil reserves. In many oil producing countries oil companies also face terrorist threats and a growing number of politically motivated attacks against energy installations and employees. In places like Iraq, Sudan, Iran, Russia, Nigeria, Colombia, and Venezuela terrorist groups and other rogue elements kidnap oil employees and target pipelines, refineries, and pumping stations to prevent local governments from generating oil revenues. Pipelines are very easily sabotaged. A simple explosive device can take a critical section of pipeline out of operation for weeks. This is why pipeline sabotage has become the weapon of choice of the insurgents in Iraq where 300 attacks took place in the past three years.

The sabotage campaign against the world's vulnerable pipelines has already brought to a cumulative loss of over one million barrels per day and is likely to continue to spread to new territories. Such assaults on oil infrastructure have added a "fear premium" of $10-$15 per barrel of oil. Governments, oil companies and pipeline operators are seeking to deploy new technologies to reduce the impact of the scourge and in some cases to increase the presence of private security companies, many employing former soldiers from western countries, to protect oil production in places where local security forces are seen as inadequate. But such solutions add extra cost to the price of each barrel which is in turn passed on to the consumer.

3. Geological depletion

The degree of geological depletion is a matter of fierce dispute in the oil industry. Almost everyone agrees that crude oil supply cannot continue to grow endlessly and that production is about to peak sometime in the first half of the 21st Century. What no one knows is when exactly this will happen. Pessimists predict peak oil by 2010. Optimists say it will not come for 30 to 40 years. Most experts expect peak to occur in 10 to 20 years. Predictions about oil depletion have been made since oil was first discovered. In 1874 a Pennsylvania geologist predicted that the U.S. has enough petroleum to keep its kerosene lamps burning for only four years. But recently serious concerns are being increasingly voiced by analysts that the world petroleum production is closer to peak than expected and supply of

conventional crude will begin to decline causing chronic shortages.[11] In fact, conventional oil production has already peaked and is declining. For every 10 barrels of conventional oil consumed only four new barrels are discovered.[12] Since the mid-1980s there has been a growing gap between annual world oil reserve additions and annual consumption. One of the main reasons discoveries have fallen is because exploration has shifted to less prospective regions. For example: in the past decade, 64% of the exploration wells drilled around the world took place in North America, where only 12% of the world's undiscovered oil and gas resources are concentrated. At the same time only 7% of the exploration took place in the Middle East, home to 28% of the undiscovered reserves.[13] Nevertheless, there are growing signs that even the more promising regions might be facing the onset of decline in production. Discoveries in the most important of the non-OPEC exporters, Russia, have reached a plateau. In November 2005 Kuwait Oil Company revealed that Kuwait's largest oilfield Burgan, the second largest oilfield in the world, has reached its peak production at 1.7mbd. In Saudi Arabia, no giant field has been found in 30 years and the probability of making new very large discoveries decreases as a producing area matures. The Saudis have estimated they have 150billion barrels beyond the 260 billions which are already proven.[14] But various reports, including those by the US National Intelligence Council and Matthew Simmons', question Saudi Arabia's claims that it can significantly expand capacity.[15]

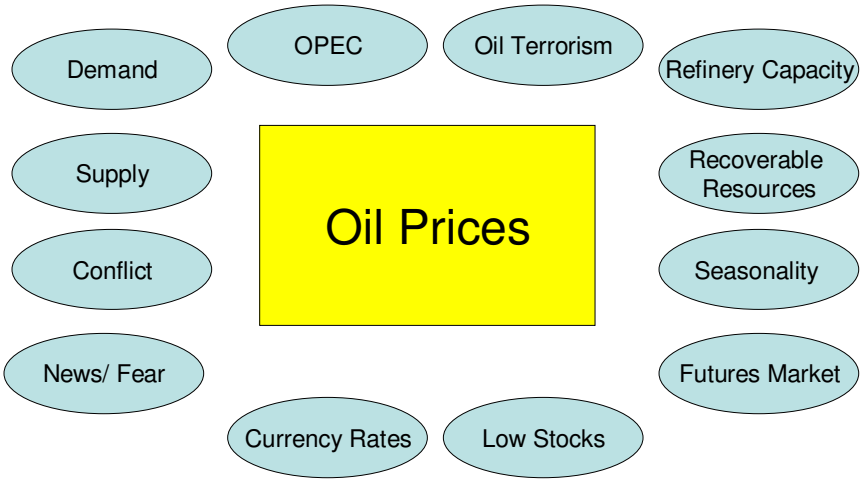
Estimated World Oil Resources (Billion Barrels)[16]

Region	Proved Reserves	Reserve Growth	Undiscovered	Total
Mature Market Economies				
United States	21.9	76.0	83.0	180.9
Canada	178.8	12.5	32.6	223.9
Mexico	14.6	25.6	45.8	86.0
Western Europe	15.8	19.3	34.6	69.7
Japan	0.1	0.1	0.3	0.5
Australia/New Zealand	1.5	2.7	5.9	10.1
Transitional Economies				
Former Soviet Union	77.8	137.7	170.8	386.3
Eastern Europe	1.5	1.5	1.4	4.4
Emerging Economies				
China	18.3	19.6	14.6	52.5
India	5.4	3.8	6.8	16.0
Other Emerging Asia	11.0	14.6	23.9	49.5
Middle East	729.6	252.5	269.2	1,251.3
Africa	100.8	73.5	124.7	299.0
Central and South America	100.6	90.8	125.3	316.7
Total World	**1,277.7**	**730.2**	**938.9**	**2,946.8**
OPEC	885.2	395.6	400.5	1,681.3
Non-OPEC	392.5	334.6	538.4	1,265.5

[11] Robert L. Hirsch, Roger Bezdek and Robert Wendling, *Peaking of World Oil Production: Impacts, Mitigation and Risk Management*, February, 2005.
[12] *Washington Post*, June 6, 2004.
[13] International Energy Agency, *World Energy Outlook 2004*.
[14] "Saudi Arabia: A Whole New Drill," *BusinessWeek*, October 10, 2005.
[15] "Doubts Raised on Saudi Vow for More Oil," *New York Times*, October 27, 2005.
[16] *International Energy Outlook, 2005*

Scenarios for the coming decade

Factors affecting oil prices



The following table presents three scenarios for oil prices in the coming decade. Oil prices will continue to be impacted by the aggregate sum of a wide variety of factors affecting supply and demand. Each one of the factors will influence oil prices to a certain degree, some for the better, others for the worse. The column titled ”best case” enumerates the positive developments which could take place in the oil market, driving prices down. The “worst case” scenario describes everything that can go wrong: increasing conflicts, wars and oil producing countries collapsing into failed states. The “business as usual” scenario assumes that global dynamics of change continue without great surprises or drastic changes in oil supply and demand patterns. Naturally, in the real world not everything that could go wrong does go wrong and vice versa. Positive and negative developments offset each other’s influence. However, when several negative developments take place simultaneously they can create a perfect storm with significant impact on the market.

	BEST CASE	Business as usual	WORST CASE
Global economic growth	Low economic growth.	Moderate to low economic growth, oil prices fluctuate with occasional supply disruptions.	Moderate to high economic growth to the point that high oil prices cause a recession.
Developing Asia	Economic growth slows down. China's growth plummets to under 4% per year due to political instability, public health and environmental problems.	Economic growth remains at current levels. China's growth levels at 6-8% per year.	Political reform and a shift to a market economy speeds economic growth to 8-10% per year.
Investment in new exploration and production	Overall investment $23billion per year for the next 15 years.	Overall investment $15-18billion per year for the next 15 years.	Overall investment under $15billion per year for the next 15 years.
Iraq	Successful transition to democracy. The insurgency is defeated. The oil industry becomes increasingly privatized. Hospitable investment climate allows multinationals to come in. Iraqi production rises to 5mbd.	Democratic system established but, by and large, the country remains unstable and fractured. Oil companies gradually increase their investment in Iraq and domestic production rises to a sustained level of 3.5mbd.	The democratic experiment fails. A Shiite theocracy is formed and the country spirals into a bloody civil war. Major energy projects are halted and the country's production declines to under 2mbd.
Iran	More progressive government takes power. The country abandons its nuclear program. Sanctions removed. Increased investment in the	Tehran continues to pursue its nuclear program but no sanctions or use of force. The country's production continues to decline due to lack of	UN Security Council sanctions are imposed in response to Iran's international behavior. Oil exports drop to under 1.5mbd. Military conflict with the U.S.

	country.	investment.	and/or Israel grinds Iran's oil industry to a halt.
Saudi Arabia	Internal security is maintained and the House of Saud maintains its grip on power. Aramco ramps up production to 15mbd.	Internal security is challenged occasionally by terror attacks which brings to the departure of Western oil workers but the country maintains a sustained production capacity of 11-12mbd.	Increased internal violence. Regime falls into the hands of fundamentalists. Saudi giant fields peak. Terror attacks against oil facilities. Production drops to under 8mbd.
Venezuela	Hugo Chavez is removed from office and replaced by a pro-American leader.	Chavez stays in power and continues his vehement anti-American policy. The country's production remains stagnant and investors are bearish.	Chavez escalates his anti-American campaign. The U.S. responds in kind. Venezuela's oil production capacity declines as a result of insufficient investment.
Russia	Renewed commitment to democracy and open market. Investors regain confidence and return to the country.	Continuation of current anti-democratic government conduct. Investors are weary of making commitments.	Continuous nationalization of the oil industry scares off investors.
Discoveries	New discoveries in the Caspian and West Africa.	Sparse new discoveries of medium size fields.	No significant new discoveries.
U.S. production	Increased hurricane activity with no damage to U.S. industry. The U.S. opens the Arctic National Wildlife Refuge (ANWR) for exploration. Production of	Increased hurricane activity with little damage to U.S. industry. ANWR opened for exploration. Production of crude from oil shale becomes economic.	Increased hurricane activity with massive damage to U.S. industry. ANWR remains closed for exploration.

	crude from oil shale becomes economic.		
Oil terrorism	Decline in global oil terrorism.	Oil terrorism remains at current level.	Terrors attacks against oil production and /or delivery systems in Kuwait and Saudi Arabia including attacks on major oil installations in the Persian Gulf.
Pipeline construction	Russia builds pipelines to Japan and China. BTC pipeline reaches full capacity. China-Kazakhstan pipeline is completed.	Russia builds pipeline to China. BTC pipeline reaches full capacity. China-Kazakhstan pipeline is completed.	BTC pipeline delivers below capacity due to technical problems and terrorist threats.
Strategic reserves	OECD nations maintain strategic reserves at current levels.	China and India establish strategic reserves.	Most major consumers establish a 30 day reserve hence adding extra demand to an already stretched oil market.
West Africa	Ethnic tension is mitigated. Increased investment in the region and Nigerian production is increased to 4mbd by 2010.	Ethnic tension continues but oil majors continue their presence in the region. Nigeria's production surpasses 3mbd.	Nigeria collapses. Oil companies leave the country. Production drops to under 2mbd.
Non conventional oil	Tar sands production rises to 3mbd. Cost reduction in production of oil from shale.	Tar sands production rises to 3mbd. Mild progress with oil shale.	Tar sands production rises to 3mbd but no progress with oil shale.
Alternative ground transportation technologies	Hybrid technology takes off. Significant breakthrough	Hybrid technology becomes widely available but there are still significant	Significant bottlenecks in the production of hybrid drive trains.

	battery technology and biomass conversion to biofuel mitigate demand for oil in the transportation sector, accounting for 5% of the fuel market.	technological barriers in the development of cellulosic ethanol. Alternative fuels account for 3% of the transportation fuel market.	Attempts to produce ethanol from cellulose at a commercial scale fail.
Projection for the coming decade (in today US$)	**$40-$55 a barrel**	**$55-$75 a barrel**	**Over $100 a barrel**

Outlook for 2015

In today's tight oil market any supply disruption could be potentially damaging and in the absence of spare capacity the likelihood of price hikes is higher than ever. There are multiple factors that can bring about such market dislocations at any given moment. The result is a remarkable state of inherent instability that is not likely to improve in the foreseeable future. The combination of lack of liquidity, natural disasters political instability and inhospitable investment climate in major oil producing countries makes the return to the old world of cheap oil in the $30-$40 range a remote outcome and could drive oil prices to a level not seen before.

Painful as the macroeconomic consequences for importing countries could be, for the airline industry high oil prices are a major setback. As fuel prices increase consumers are expected to pay more for transportation. If the price of crude climbed to $100 a barrel, for example, jet fuel would surpass $3 per gallon. A passenger flying coast to coast in the U.S. will pay $50 extra. For cargo carriers the implication could be loss of market share to ground carriers and a sharp decline in profits. But high oil prices also have an indirect impact on the industry due to the slowdown of the economic activity throughout the world.

High prices bring to an increase in the cost of manufactured products and the national debt of consuming countries. Disposable income drops and the volume of international trade shrinks. The World Trade Organization announced that lower economic output, brought on in part by the sharp rise in oil prices, slowed world trade growth in 2005.[17]

Since the 1970s, the world economy has grown resilient to fluctuations in oil prices. The reason is that the amount of energy needed to produce each real dollar of GDP has fallen by 50%, a decline of about 2% per year. In the U.S., for example, low interest rates and lower taxes have increased consumer spending and mitigated the inflationary pressure caused by high oil prices. But this

[17] *International Trade Statistics 2005*, World Trade Organization.

resilience can only hold to a certain extent. Developing and transition economies, particularly heavily indebted poor countries, are likely to suffer the most from rising oil prices as their economies are more oil-intensive and less able to weather the financial turmoil wrought by higher oil-import costs. According to the IMF, a $5 increase in the price of oil shaves off about 1% of GDP.[18] Such an increase would worsen the current account deficits of those countries, limit their access to international capital markets and bring about a transfer of wealth from consumers to producers.

Potential solutions for the oil crisis

Conservation

Industrialized nations have demonstrated remarkable ability to conserve and improve efficiency once prices spike. Between 1979 and 1985, in response to OPEC's oil embargo U.S. oil consumption fell 15%. Because 60% of the projected increase in oil use in the next 20 years will be in the transportation sector, the biggest efficiency gains can be accomplished there. Roughly 40% of the world's supply goes to power cars and trucks. Public policy initiatives such as gasoline taxes, fuel efficiency standards for cars and trucks and the introduction of austerity measures could dampen demand and push prices down. Many countries have introduced fuel efficiency standards with varying levels of success. After fuel economy standards were introduced in the U.S. in 1978, the fuel efficiency of new cars and trucks rose quickly but it has since leveled off. In 2004, China implemented fuel economy standards that are based on European standards and tougher than those in the U.S.

The introduction of hybrid technology which combines an internal combustion engine with an electric motor allows auto manufacturers to increase efficiency without compromising safety or performance. Because of their high efficiency, hybrid electric vehicles can attain from 20% better to over twice the mileage of a conventional gasoline engine. But while conservation in the transportation sector is desirable one should not overstate its benefits. It takes a long time to replace the on road vehicle fleet so even if fuel economy standards are imposed it will take more than a decade for their effects to be fully felt as new vehicles displace old ones.

[18] International Monetary Fund, *The Impact of Higher Oil Prices on the Global Economy*, December 2000.

Enhanced recovery technologies

If oil production were to grow significantly it would be due to better utilization of known reserves rather than due to new discoveries. Technology will underpin these increases. Extended reach drilling, advanced reservoir imaging and enhanced recovery techniques enable oil companies to find, reach and produce resources in ways not possible just a few years ago. Such technologies enable producers to tap into the vast reserves of oil and gas beneath the sea and recover oil from declining fields. Currently, recovery rates stand on 20-40% of the original oil in place. Enhanced recovery techniques offer prospects for producing as much as 60%. According to the U.S. Department of Energy up to 337 billion barrels worldwide can be recovered through injection of natural gas, nitrogen, chemicals, steam and CO2.[19]

Non conventional sources

Very often one hears the argument that the depletion of conventional oil supply will be offset by the production from non-conventional sources, mainly oil from tar sands in Canada and the extra heavy oil deposits in Venezuela. About 1.2 trillion barrels of extra heavy oil are in place in Venezuela. At current technology and prices only 2-3% of this endowment is economically recoverable but it is likely that 100-270 billion barrels will eventually be economically recoverable. In Canada, there are close to 180 billion barrels which could potentially be derived from Alberta's tar sands, making Canada second to Saudi Arabia in oil reserves. Of this endowment, about 20% are economically recoverable at current market conditions. Getting the oil out of the sand is expensive and complicated. It takes about two tons of sand to extract one barrel of oil. If oil prices remain near current levels oil-sands production would be profitable. There are also an estimated 800 billion barrels of oil contained in oil-shale deposits in Colorado, Utah and Wyoming. That is more than triple the proven oil reserves of Saudi Arabia. But with the currently available technologies, analysts say that crude-oil prices would have to rise to somewhere around $70 a barrel, and stay there, in order to make extraction financially viable.

Despite the significant potential reserve of non-conventional oil, shifting to such energy resources requires enormous investment and a long lead-time. Furthermore, the energy required for the extraction of such non-conventional sources of crude is so huge as to almost offset the amount of energy the extracted oil ultimately yields. Also the cost of production is high and there are severe environmental problems. By 2010 only 4% of the world's oil will come from non-conventional sources, but clearly the next several decades will offer an increasing role for these energy sources.

[19] U.S. Department of Energy, Enhanced Oil Recovery/CO2 Injection http://www.fe.doe.gov/programs/oilgas/eor/

Strategic reserves

To compensate for the erosion in OPEC's spare capacity, major oil consuming countries are taking steps to insulate their economies from supply disruptions by creating liquidity mechanisms of their own. The U.S. keeps a strategic reserve of over 700 million barrels, which can provide 1mbd relief for up to a year. European and Asian consumers are also creating such oil banks albeit at a much smaller extent. While certainly costly to build, strategic reserves would have the long-term benefit of keeping the market liquid and hence reducing the economic impact of supply disruptions.

Shift to alternatives

Throughout the world alternative fuels make a mere 2% of the transportation fuel market. But rising oil prices have brought to a spike in demand and in production of gasoline replacements. In many countries motor fuel is blended with ethanol, an alcohol fuel made from corn or sugar cane. In Brazil, for example, ethanol accounts for 20% of the country's transportation fuel market today.[20] Flexible fuel vehicles can use any combination of gasoline and alcohol and cost under $150 to manufacture over gasoline only cars. Millions of them are already on the road. Over the last three years in Brazil, the share of new car sales that have fuel flexibility has risen from 4% to 67%. In the U.S. major automakers have indicated their plans to ramp up production of such cars.[21] Biodiesel made from plant oil is becoming increasingly popular. While global production of ethanol has more than doubled since 2000, production of biodiesel has expanded nearly threefold. This trend is going to continue. The biggest producers of biofuels--Brazil, the U.S., the European Union, and China--all plan to more than double their production within the next 15 years. No doubt the potential for biofuels is huge. According to the World Watch Institute the world could theoretically harvest enough biomass to satisfy the total anticipated global demand for transportation fuels by 2050.[22] But there are still significant barriers. Biofuels cost more than petrol and in some cases take more energy to produce than the petroleum they aim to replace. Technologies to convert cellulosic material to ethanol are still in the experimental stage and will take years to commercialize. Furthermore, dependence on the agricultural sector presents new threats to the transportation fuel market like droughts, floods and disease.

In recent years a great deal of attention was given to hydrogen. Hydrogen enthusiasts claim that when hydrogen is used to power fuel-cell vehicles it will do so with more than twice the efficiency of today's gasoline engine and with zero emissions. But for now this vision is far from reality. Using hydrogen as an automotive fuel entails multiple technological difficulties as well as safety and infrastructure problems that to date have not been satisfactorily resolved. In the

[20] "Bumper Crop," *Wall Street Journal*, January 9, 2006.
[21] "Ford, GM Make Big Push to Promote Flex Fuel Vehicles," *Wall Street Journal*, January 9, 2006.
[22] *State of the World 2006*, Worldwatch Institute, 2006, p. 74.

long run, hydrogen may perhaps be a potential future fuel. But more and more studies show that in the next two decades no significant market penetration is expected.

More promising an approach is the use of electricity as a transportation fuel. In most of the industrial world petroleum is no longer used to generate power. Since the 1970s oil powered generators have been replaced by nuclear reactors, coal fired power plants, natural gas turbines and, to a lesser degree, solar panels and wind turbines. In order for these electricity sources to displace petroleum electricity must become a transportation fuel. This can be done by using a new vehicle technology that is a small step technological forward beyond hybrid electric vehicles: plug-in hybrid electric vehicles (PHEVs). Such vehicles can be optionally plugged into the electric grid and provide the stored electric energy for much of a typical day's drive. Like no-plug hybrids, PHEVs have an internal combustion engine and liquid fuel tank, and thus do not face the range limitations of electric-only vehicles.

In sum, technology exists today to enable next generation fuels and cars to penetrate into the market in significant numbers. There is little doubt that technology and innovation, along with steps toward conservation, will ultimately reduce the share of petroleum in the transportation fuel sector. But such a development will take time, and until this happens, oil will remain the lion share of the world's fuel mix.

Policy options for the airline industry

No doubt the air transport industry is among the most efficient of all the energy intensive sectors of our modern economy. Aircraft produced today are about 70% more fuel efficient then those of forty years ago. The industry has been able to increase its fuel efficiency by 1% a year for the last three decades, which translates to a saving of about 80,000 gallons of fuel for every plane every year. A further 20% improvement in fuel efficiency is projected by 2015 and a 40 to 50% improvement by the middle of the century. Such progress has been achieved through a combination of technology, improved air traffic control and better practices.

Increase fuel efficiency

In the past three decades the aviation industry has worked diligently to reduce airplane fuel consumption. As a result newer airplanes are twice as fuel efficient as those built 30 years ago. Compared with 50 years ago, the reduction is an even more dramatic – 70%. Much of the efficiency gains were achieved through improvements in the combustion process and the use of advanced materials which allow engines to operate under higher temperatures. Improvements in

aerodynamic designs and introduction of lightweight materials have decreased the weight and drag of modern airplanes. Improved maintenance practices have also minimized unnecessary fuel consumption. Companies like Rolls-Royce, General Electric and Pratt Whitney project fuel efficiency improvements of as much as 10% by the end of the decade. There are other promising energy saving technologies to reduce drag and allow planes to save fuel. Companies like Southwest and Continental Airlines have installed "winglets" -- curled-up wing ends – on their 737s. Though the retrofit costs about $700,000 per plane, high oil prices ensure fast return on investment. Fuel savings of about 3% to 4% has been achieved through this technology alone.[23] Another technology, FuelMizer, provides an additional 4%-plus fuel savings by repositioning the aft flap segments to increase wing camber. [24] Fuel efficiency can also be improved through austerity measures on the ground such as taxiing on a single engine, balancing the load, and plugging in aircraft on the ground to auxiliary power units, to use electricity, rather than liquid fuel.

Improved air traffic management

When airplanes fly the most direct routes and spend less time idling before takeoff and after landing, less jet fuel is used. Advanced air traffic management technologies available today for aviation communications, navigation, and surveillance (CNS) systems improve airline fuel efficiency by enabling planes to calculate the most efficient routes and altitudes to take more direct routes between destinations, use more airspace at currently prohibited lower elevations, and minimize time waiting for landing and take-off strips. Airlines can develop and introduce sophisticated flight planning software that can better calculate the effects of wind and weather patterns. According to the U.S. Department of Energy, CNS improvements can reduce commercial jet fuel consumption by 5% by 2020. The International Air Transport Association (IATA) is even more optimistic claiming that "worldwide, airlines could reduce their fuel consumption by us to 18% with optimized air traffic control."[25] Unfortunately, since airlines are dependent upon regulatory and air traffic authorities they do not have total freedom to initiate self-help measures. Since air traffic is set to double in the next two decades improvement in air traffic management is not only an economic imperative but also a safety issue. Permitting airlines to select their own routes could save significant amounts of fuel but this has to be done in ways that do not compromise safety.

Shift to non-petroleum jet fuel

Higher oil prices are gradually encouraging the development of some alternative-energy resources as replacements for traditional petroleum products. Though many of these non-petroleum fuels carry a great deal of promise for the ground

[23] "Cutting Fuel Costs," *Overhaul and Maintenance*, July 25, 2005.
[24] "Burn Less, Save More," *Air Transport World*, November 2004.
[25] "IATA: Better Traffic Control would Save Fuel, *Reuters,* July 13, 2005.

transportation sector, it is less clear whether such alternatives are viable for the aviation industry. Virgin Atlantic Airways CEO Richard Branson said he has undertaken plans to run his planes on alternative fuels manufactured from plant waste.[26] Most experts, however, hold that this vision is unrealistic since none of the conventional fuel systems are likely to be able to handle these fuels in the foreseeable future. The main problem biofuels pose for aircraft is that their energy density is lower than that of conventional jet fuel. This means that more fuel will have to be carried on board which will, in turn, increase drag and fuel consumption as well as more frequent refueling.

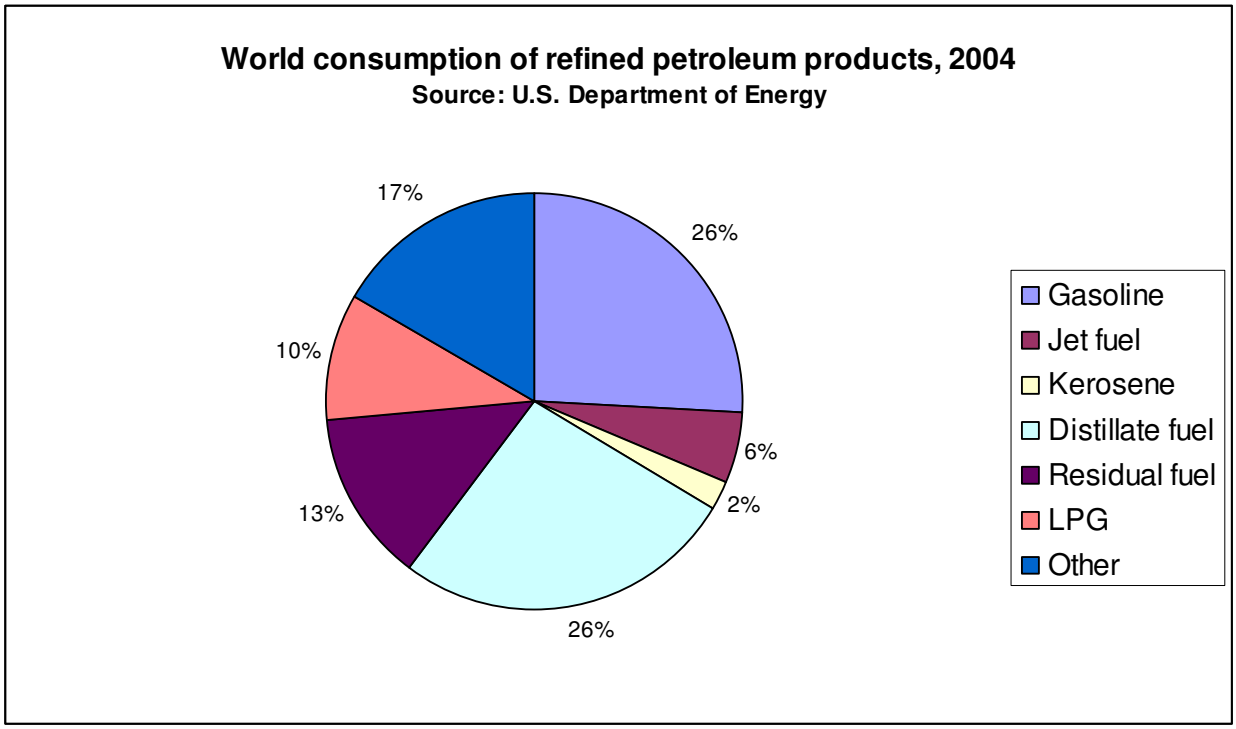
Much more promising is the prospect of producing synthetic jet fuel from coal and natural gas. The South African petrochemical company Sasol is renowned for producing clean burning fuel from coal. Aircraft flying out of Johannesburg International Airport already use semi-synthetic fuel made of 50% coal-derived jet fuel blended with 50% traditional petroleum derived jet fuel.[27] A growing number of world fuel authorities are in the process of approving the fuel for wide use.
The company is also a leader in gas to liquids (GTL) technologies. GTL technology involves transforming natural gas to liquids via Fischer-Tropsch processes. Further upgrading of the liquids produces a range of super clean fuels that can be blended into conventional fuels and used in existing engines both on the ground and in the air.

Conclusion

While the airline industry is doing all it can to minimize costs by reducing its fuel consumption, it has little influence on overall demand and global oil prices. Air transportation accounts for only 6% of the world's demand for refined petroleum products. Even if the industry achieves a 20% efficiency improvement in the coming decade, as many hope it will, this will save the equivalent of 1 million barrels a day to the global oil market. This gain will be offset by an increase of 18mbd in global demand for oil which is currently projected for the same period of time. Being a marginal consumer with limited capability to affect global oil prices the air transport industry should look beyond minimizing its own fuel bill. The industry should seek ways to affect the market at large and help reduce oil prices. The sector where substantial oil savings can be achieved, in sufficient quantity to drive down oil prices, is ground transportation. This sector alone consumes over half of the world's refined petroleum products. Therefore, in addition to all the internal measures the air industry has taken it should also support from the outside policies aimed to increase supply and reduce demand for oil in the ground transportation sector. Unlike in the air, the ground transportation sector can, given current technologies, relatively easily shift to using alternative fuels such as ethanol, methanol, biodiesel, electricity, and natural gas. Many countries have introduced policies which mandate and/or

[26] "Virgin Airways Boss Eyes Plants for Fleet Fuel," *Reuters*, November 16, 2005.
[27] "Flying High on Coal," *Engineering News*, December 7, 2005.

provide incentives for the deployment of alternative fuels and the cars that can run on them. Japan, for example, announced recently that it will lower its oil dependence in the transportation sector from nearly 100% to 80% by 2030.The displaced 20% would be filled in by non-petroleum fuel sources.[28] Such a reduction alone would free close to 2mbd from the ground transportation sector.
Sweden recently announced that it plans to become the world's first oil-free economy by focusing in the next 15 years on a shift to renewable energy.[29]
Oil saving initiatives are currently being deliberated in the U.S. where almost 9mbd are used to power cars and trucks. In his 2006 State of the Union Address, President George Bush declared that "America is addicted to oil," and proposed to reduce oil imports from the Middle East by 75% over the next twenty years. Bills pending in the U.S. Congress propose oil saving of 2.5mbd by 2015, using existing vehicle and fuel technologies. Such national energy initiatives are long overdue. Given high oil prices and continuing instability most consuming countries are likely to look inward and try to devise policies designed to reduce their oil consumption only to be met by resistance by defenders of the status quo. This is where stakeholders from highly affected industries could tip the balance in favor of such measures. With its centrality in the modern economy and its political influence the air transport industry could play an important role in this transition.



[28] "Gov't to seek cut in oil dependency," *The Yomiuri Shimbun*, January 6, 2006.
[29] "Sweden Wants to be Oil Free by 2020," *Guardian*, February 7, 2006.