THE FUTURE OF OIL AND THE ENERGY MARKET

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by

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Abstract

The goal of this study is to predict the future of the oil market, economic consequences of increasing oil scarcity, and the likely future development of an alternative energy infrastructure based on nuclear power and hydrogen. It was estimated that world oil production capacity will fall short of needed demand by at the very latest after 2020. The increased price of oil will motivate the construction of an alternate energy infrastructure. The likely alternative fuel which will replace oil in the transportation sector will be hydrogen.

Table of Contents

List of Figures

List of Tables

Chris Weikel

The Future of Oil and the Energy Market

Introduction

Since the model T entered mass production the lifeblood of Western technological society has been oil. In the transportation sector petrochemicals such as gasoline and diesel have no substitute and modern technological civilization cannot go back to horse drawn carriages. Oil has many applications but its most crucial application at the present time is for the gasoline and other fuels (such as diesel) which are used in the engines of cars trucks and planes. The essential industry of modern agriculture is dependent upon oil based fertilizers and gas guzzling farm machinery. Furthermore plastics are refined and chemically produced from oil. Also at the present time oil is burned to produce electrical power, though as it becomes more critical as engine fuel this is likely to be phased out. Thus Oil prices have a strong effect on the economies of all industrialized nations which as of now are addicted to black gold.

After WWII abundance of oil has brought great wealth and power to formerly primitive Bedouin tribes. In WWII lack of oil brought the axis powers to a halt in WWII (The 3rd Reich faced a severe shortage particularly as the demands of an all out war on

the Eastern Front grew greater[116], Admiral Yamamoto predicted the basic outcome of the war if Pearl Harbor were to be attacked *"In the first six to twelve months of a war with the United States and Great Britain I will run wild and win victory upon victory. But then, if the war continues after that, I have no expectation of success."*[117], he knew Japan would exhaust its store of oil after that time and be incapable of waging war). Given oil's indispensability in many economic sectors, and its critical importance in waging war a reliable supply is not only an economic issue but one of national security.

Demand for oil has increased since WWII and only looks to go up in the future. Increased demand must be filled by increased production. Any future increases in oil production in response to demand looks like it will primarily come from 3 regions 1) Around the Persian Gulf 2) From Africa and 3) From around the Caspian sea.

At the current time there is no substitute for petroleum energy in many critical sectors especially transportation. The percentage of oil consumed in the US transportation sector as a fraction of the total oil consumed in the US is shown in figure I-1.

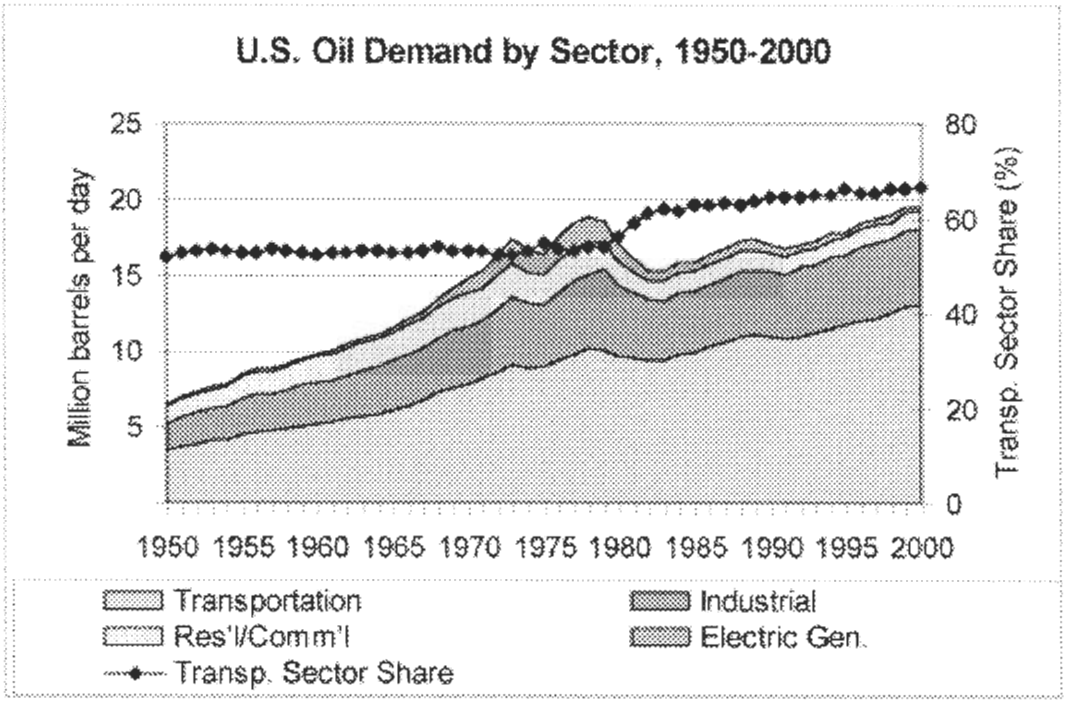

Figure I-1: US Oil Demand by End Use Sector[118]

The United States is unfortunately, along with other major oil consumers is increasingly dependent on oil imports. The US, as shown in figure I-2, must import about 278 million barrels per month(250 million is 90% of our needs) and about 60% of our total oil demand.

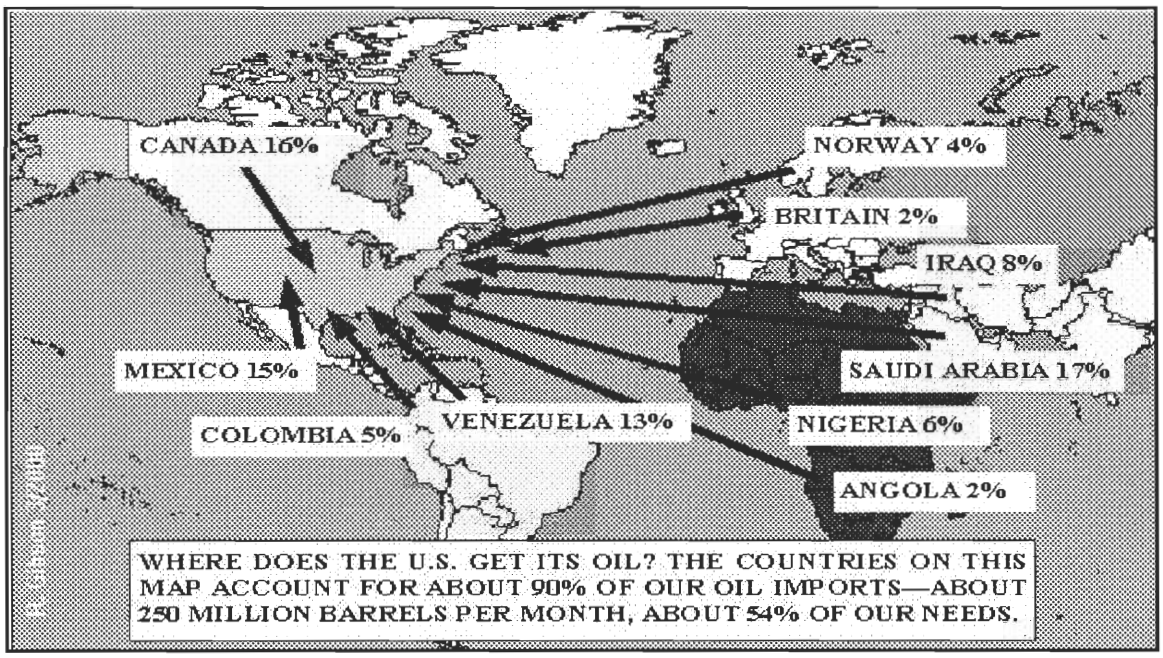

Figure I-2: US Oil Imports By Country as a % of Total US Oil Demand[119]

As oil supply falls short of demand the need to rectify this problem will become more pressing and more economically feasible as oil energy becomes more expensive and energy cost and supply shortfalls begin to seriously hurt the US and global economy. An economy based on substitutes for oil cannot be built overnight and if no groundwork is done before things reach crisis levels the economic adjustment to the end of the cheap oil era will be more painful.

This paper will attempt to predict the future demand for oil by examining Asia and China in particular. It will also attempt to predict to the extent possible, given limited information and the numerous dynamic variables, possible future oil production (supply) capacity. Then, based upon the gap in supply vs. demand, the future gap between supply capacity and world oil demand will be calculated. The potential economic consequences of an energy shock based upon a shortfall in oil capacity will be

discussed, for the United States and the world in general, including how it will likely give rise in the long term to an alternate energy infrastructure. Finally the paper shall recommend steps to be taken now to better prepare for the inevitable.

Chapter 1: History of the Oil Market from the Early 20th century to the OPEC embargo

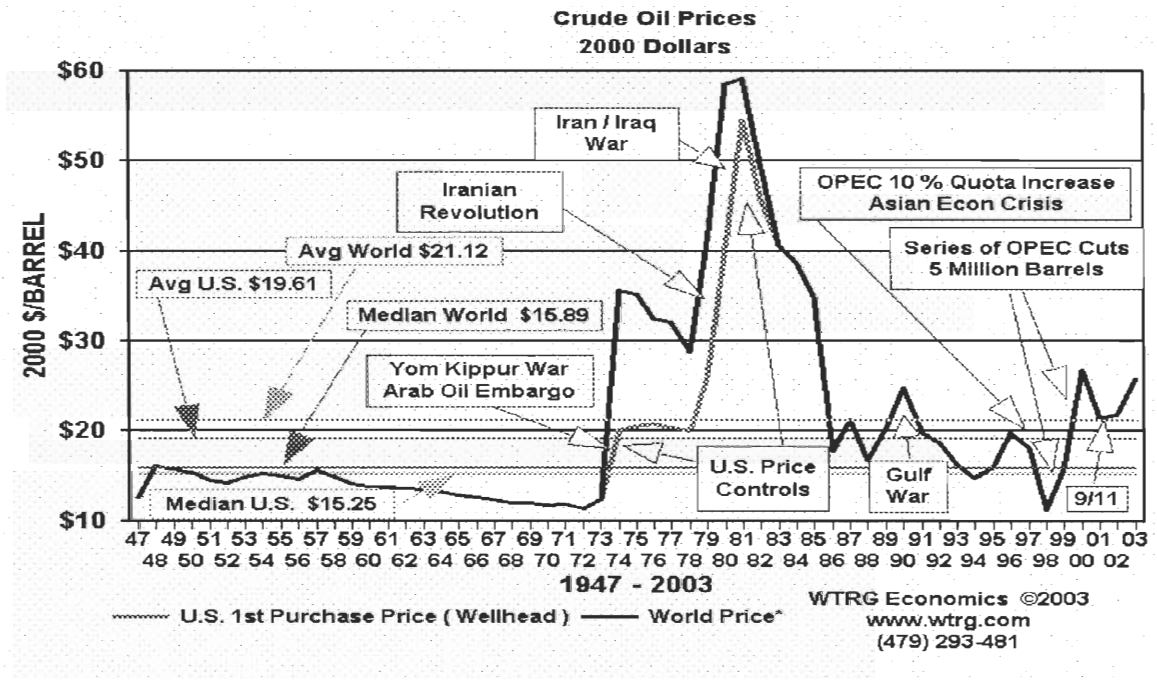

Figure 1-1: Oil Prices vs. Events indexed for inflation to year 2003[18]

The above figure shows oil prices indexed for inflation to the year 2000 from 1947 to 2003. It shows a period of stable and low prices before the OPEC oil embargo ended by the massive oil pumping due to the Iran/Iraq war followed by an unstable prices(though lower then during the artificial oil shocks) afterwards.

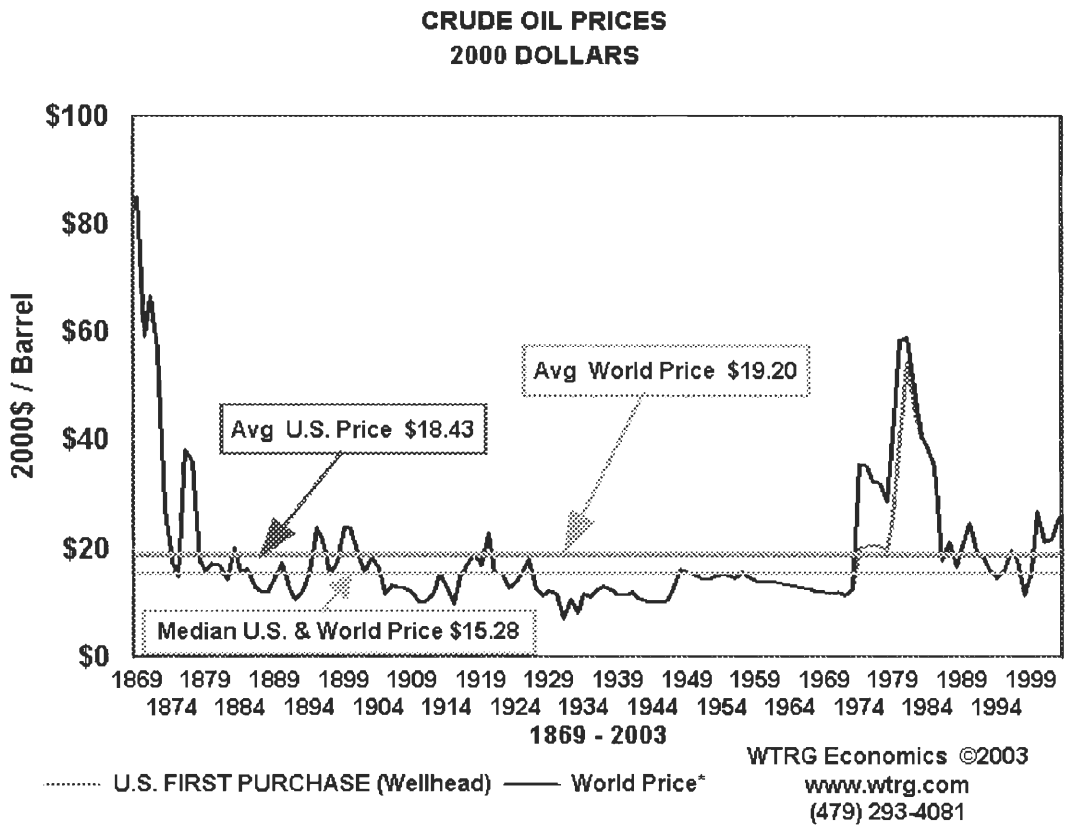

Figure 1-2: World and United States Oil Prices 1869-2000[18]

Figure 1-2 shows oil prices from 1869 to 2000, it shows for that for most of the 20th century(especially corresponding with the advent of widespread auto use) oil prices were low in 2000$ terms, reflecting abundant supply to meet demand. This provides a likely contrast with the future.

Favorable Situation for Major Oil Consumers from 1869 till the Arab Oil Embargo

Between the 1920's and the OPEC nationalizations the world oil market was mostly controlled by 7 oil companies. These were British Petroleum, Royal Dutch Shell, Texaco, Mobil, Gulf Oil, Standard Oil or California, and Standard Oil of New Jersey (of which all the major American oil companies were partially spawned from the antitrust

breakup of Standard Oil). Before the 70's these companies essentially dictated the price and production of oil in the Middle East.

"The role of the firms known as the "Big Seven Sisters" in the oil-producing states on the Persian Gulf is legendary. For a long time they controlled the production, refining and marketing of virtually all Arab oil. " [21]

Because of abundant Domestic production in the US (which was a net oil exporter till the Mid 1950s, R-20) and a rate of oil discovery that outpace consumption prices remained low and the Western World in particular the US were energy independent. To the extent the world was dependent on Middle Eastern imports the 7 sisters kept prices low and the oil producing states from getting much of a cut of the money.

Chapter 2: Rising Oil Demand

China

Preference for Coal and Domestic Oil Supply

China relies upon Coal for about 64% of current energy needs[11] and will likely continue to use Coal as its main energy source rather then depend on other fossil fuels less abundant domestically. China's Shenua Group is currently constructing a coal liquefaction plant[11] in Inner Mongolia which hopefully will allow a refined liquid coal substitute for Petroleum for some of its transportation needs. China has proven domestic oil reserves of 18.3 billion barrels[11] and oil production of 3.39 million barrels per day[11] but oil production seems to be flat and any rise in consumption will likely have to come from imports.

Projected Passenger Car Ownership and Oil Consumption

The Chief engine driving future increases in the world consumption of oil in the future will most likely be China. With over one billion people and a rapidly growing economy, automobile ownership in the PRC is certain to expand. According to the October 2003 issue of Automotive News[1] passenger car sales in China were up 83% in the 1st half of 2003.

According to the Chinese People's Daily[10] the number of cars in China will top 156 million by 2020. This may be an underestimation as Hyundai alone estimates they will be selling more then 500,000 cars a year in China by 2008[1]. As China's transportation infrastructure expands along with its industrial base car sales will in all likelihood increase after 2008.

The Average US passenger car consumes about 550 gallons of gasoline per year[2]. One "barrel" of oil equals 42 gallons which from which, after the oil is refined about 25 gallons of gasoline are obtained. So each passenger car consumes about 22 barrels of oil a year.

So if China has similar fuel consumption rates per car, and there are 156 million active passenger cars in China[10], and barring any improvements in the refinement process, China will require 3.4 billion barrels of oil a year for gasoline or 9.4 million barrels per day per gasoline alone. That's more then the current production of Saudi Arabia[3]. Though for industrial uses China primarily uses coal, it uses more industrial heavy fuel and heating oil (barely refined crude) then gasoline. If the rate of heavy fuel oil use keeps pace with the increase in gasoline China could be consuming 25 million barrels per

day by 2020. That's above the US rate of consumption for 2002 of 19.7 million barrels per day[4].

The possible Chinese oil demand(in 2020) was obtained using the oil consumed by each passenger car and each scenario for total demand was obtained by using that number as a fraction of total Chinese oil demand.

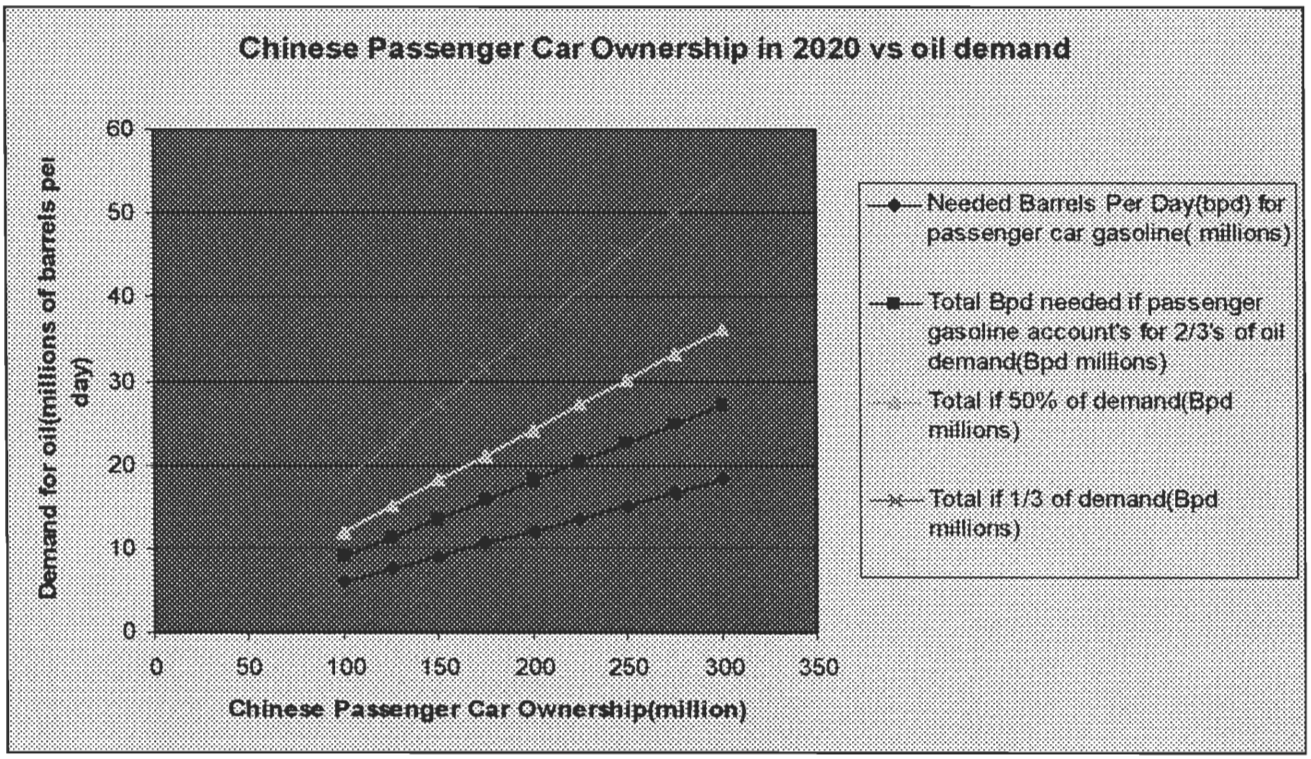

Figure 2-1: Oil Demand vs. the Total Number of passenger cars in China

Figure 2-1 shows projected oil use vs passenger car ownership in the year 2020.

The Graph was generated as an excel plot using the data in Table 2-1 below

A.	B.	C.	D.	E.
100	6.02	9.04	12.05	18.08
125	7.53	11.30	15.06	22.60
150	9.04	13.56	18.08	27.12
175	10.55	15.82	21.09	31.64
200	12.05	18.08	24.11	36.16
225	13.56	20.34	27.12	40.68
250	15.07	22.60	30.13	45.20
275	16.58	24.86	33.15	49.72
300	18.08	27.12	36.16	54.24

Table 2-1: Data Table For Chinese Passenger Car Ownership vs. Oil Demand

A. Chinese passenger car ownership in 2020(millions of cars)

B. Oil consumption of passenger cars(millions of barrels per day) based on the 22 barrels per car per year formula

C. Total Chinese oil consumption(millions bpd) if passenger cars account for 2/3 of total Chinese oil demand.

D. Total Chinese oil consumption(millions bpd) if passenger cars account for ½ of total Chinese oil demand.

E. Total Chinese oil consumption(millions bpd) if passenger cars account for 1/3 of total Chinese oil demand.

Economic Analysis of the Effects of Rising Chinese Oil Demand

As stated above, The People's Daily predict passenger car ownership will be about 150 million in 2020. The writer leans towards a higher number because of China's skyrocketing economic growth and population of over a billion people.

Conservatively it is likely China will have between 150-200 million passenger cars accounting for between 2/3rd's and 50% of the demand for oil consumed in China. Thus Chinese oil demand in 2020 will likely be between 17 and 20 million barrels of oil per day, barring any breakthroughs in fuel efficiency or large-scale conversion to alternative energy.

This is close to the current US rate of consumption of 19.5 million barrels per day[5] and would account for about 22% of current world oil production and a tripling of its current oil consumption of 5 million barrels per day[6]. Overall Asian demand currently stands at 21.6 million barrels per day[7] with 16.6 million if China is excluded. If the rate of growth in oil consumption in the rest of Asia is half of China's(a conservative estimate given that oil consumption is likely to go way up in all of Asia except Japan and Burma) then the rest of Asia will need 24.9 million barrels per day. Adding that total to China yields a conservative total of 42 million barrels per day, about 20 million barrels more then current Asian oil consumption and more then half of current world oil production. Oil production in Asia is relatively flat so this increased production will likely cause the price of oil to skyrocket as most of Asia's oil will have to be imported.

India

Domestic Oil Supply and Diesel Fuel

India has proven oil reserves of 5.4 billion barrels and currently produces 759000 barrels per day. Production as with China is likewise not expected to increase dramatically[11].

The increase in Indian demand will be dampened somewhat by the fact that most Indian vehicles are equipped to use diesel fuel, which is cheaper there then gasoline [13]. 7% of passenger cars sold there use diesel

Rising Oil Demand

Indian demand is also rising, while India has a projected oil reserves of 5.4 billion barrels, drilling there has a recovery rate well below the world average(partially due to state owned companies lack of competence compared to private companies, not so much geology)with the result most Indian oil is not competitive with foreign producers. Also local production probably cannot keep pace with the growth in demand. India population estimates very between 800 million to 1.2 billion people. With rapid economic growth in India in a decade or two the per capita energy consumption of such a large number of people will likely grow dramatically in a few decades pushing up demand.

"Future oil consumption in India is expected to grow rapidly, to 3.2 million bbl/d by 2010, from 2.0 million bbl/d in 2002."- [12]

Still India's oil consumption is expected to rise to 4.1 million barrels per day by 2020[15] more then double its current consumption.

Summary

China and India will thus likely cause a great increase in global oil consumption over the next 2 decades, about 20 million more barrels. Much of that will probably be supplied from the unused capacity of the Arab and particularly Saudi dominated OPEC oil cartel. Assuming the rest of world oil consumption rises by half of that figure world oil consumption will increase from 76[16] millions of barrel per days currently to 106 millions of barrels per day in 2020. This is an optimistic figure as many[17] have predicted consumption of about 120 million bpd based upon a 2.2% annual world economic growth rate. These two numbers establish a good range for possible world demand for oil in 2020.

Chapter 3: Oil Exporting regions in the present and projections of oil Production in the Future

The Middle East

Saudi Arabia

Saudi Arabia has 260 billion barrels of proven reserves, about ¼ of the world's total[23]. 90% of its oil currently is produced in 5 giant fields. Saudi Arabia's current oil capacity is about 10.5 million barrels of oil a day and it's currently producing about 8.3 million barrels of oil per day[64].

> "Saudi Aramco's current operations encompass 1.5 million square kilometers, comprising 85 fields, 320 reservoirs and 25% of world oil reserves. Current daily production capability stands at 10 million barrels of crude oil and 9.6 billion cubic feet of gas. The Company's strategy calls for an annual reserves replacement of its crude production, while adding 5 trillion cubic feet gas reserves through an integrated exploration, delineation and development program."[72]

Saudi Arabia's infrastructure, befitting its reserves is the Largest in the world but dependent on 2 major ports and a 750 mile long pipeline that is vulnerable to attack by Islamic terrorists [25]. The average Saudi price of extraction is about 1$ per barrel, currently the cheapest in the world[22]. Saudi Arabia currently has an unused oil capacity estimated at 2 million barrels per day [26]. The highest in the world but not enough to keep up with the projected growth in world demand. Saudi Arabia also dominates the OPEC oil cartel as it can threaten to use its unused capacity to flood the market and lower prices for everyone and has done so in the mid 1980's. Thus the opinion of the Saudi's is "listened to" at OPEC meetings.

Future Supply Projections of Saudi Oil Production

The limited information available from Aramco seems to be more pessimistic and predicts that at least at current oil prices oil production will peak at around 12-13 million barrels of oil per day[65].

The folks at the conservative site Dieoff.org have prepared a graph of Saudi production (billions of barrels per year) that does not anticipate much of an increase in production and predicts Saudi's peak in 2011 at approximately 10.8 million barrels per day[69].

Optimistically if Infrastructure is expanded the country, given its large reserves could probably increase production by at least another 10 million barrels per day. Given that the US has oil reserves of only 22.7 billion barrels(including the untapped sources in the Alaskan wildlife refuge) but produces about 7.9 million barrels per day[120], Saudi Arabia, if aggressively develop of its oil infrastructure should be able to produce at least 18 million barrels per day by 2020. Though the increased oil production may not come at as cheap an extraction cost as the oil currently being produced.

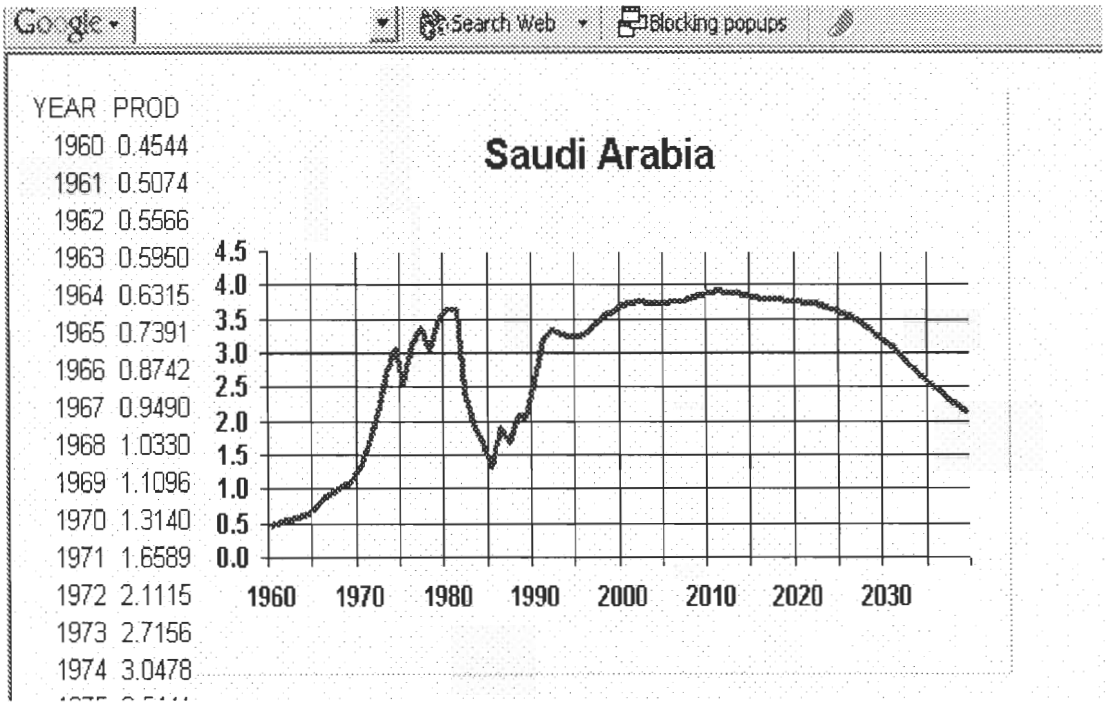

Figure 3-1: Pessimistic Prediction of Saudi Oil Production (Billions of Barrels Per Year)[69]

This Graph based on the work of geologist Dr Richard Duncan who predicts Saudi Arabian oil production (at least at current price levels) to peak in 2011 at a production level of about 10.7 million barrels of oil per day(the drop in Saudi production in the early 80s till the 90s was due to a number of factors, when the oil embargo ended the Saudis had a surplus of oil not sold in the embargo so they did not need to produce at full capacity, and the oil shock caused by the embargo caused a long term fall in oil demand as cars became more efficient along with oil based heating systems).

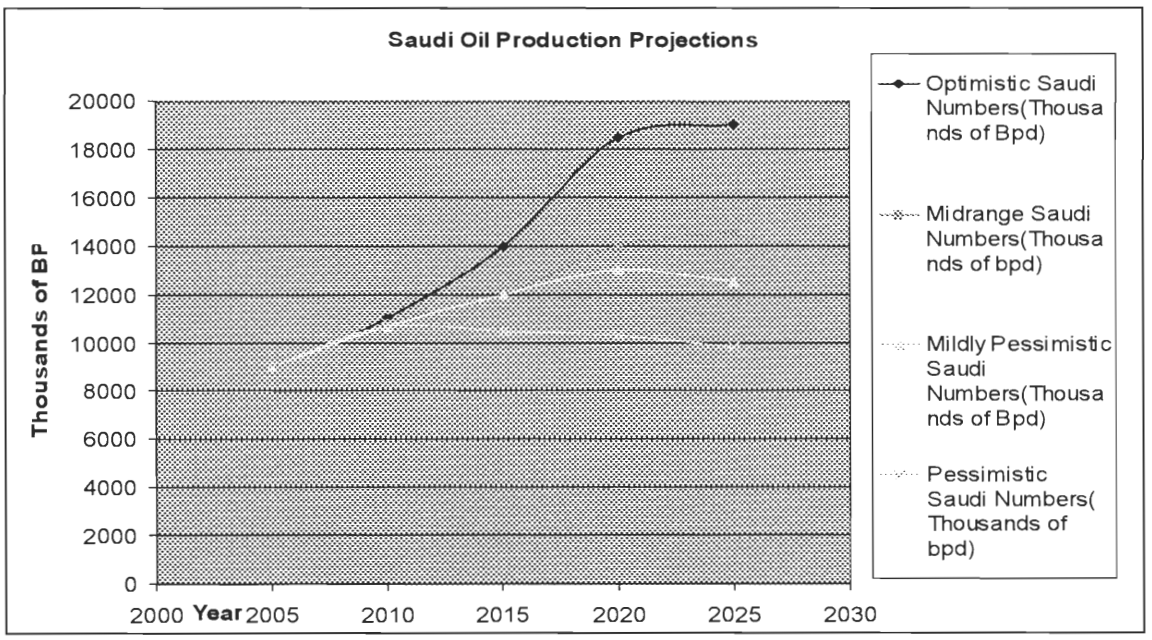

Figure 3-2: Scenarios For Future Saudi Oil Production

The Optimistic Curve- is based on the thinking that Saudi oil can rise a great deal to meet world demand and that large production increases are possible given its large reserves, such a scenario is possible given the high US production with reserves of far less oil. Nevertheless given declines in production in existing large oilfields its unlikely production will reach 20 million barrels per day.

The Midrange Curve is based on anecdotal evidence given by Aramco[65] not to expect production to increase to much more then 12-13 million bpd with some optimism production will rise a little bit to meet demand at perhaps a higher price level. The production rises to 12 million by 2015 and 14.5 million by 2025.

The mildly pessimistic curve is based on a stricter interpretation of the comments of Aramco officials which expects Saudi production to peak at around 13 million barrels

per day and then steadily decline ala Hubbert. The curve essentially follows the other midrange till 2015 but then only increases to 13 million followed by a decline.

The Pessimistic Curve is based Dr Richard Duncan's[69] prediction of Saudi production peaking in 2011 with a steady decline thereafter. The billions of barrels per year figures from Figure 3-1 are merely converted to millions of barrels per day.

The Geopolitical Role of Saudi Arabia and the War on Terror

The Country with the greatest estimated oil reserves and also the cheapest oil to drill on the planet is a cultural, religious, and political basket case. And the world depends on this country for oil production.

Saudi Arabia is the home to the Wahabbi Islamic sect, probably the most extreme and intolerant religion on the planet. No other religion besides Islam is permitted in Saudi lands; strict application of Shariah (Islamic law as given in the Koran) forms the basis of the legal system. Intolerance is preached in the Mosques and legislated by the state [27].

Wahabbi history has no tolerance for any deviation from its strict puritanical creed, Islam is not a tolerant religion in general but Wahabbism is far less so.

The Saudi government finance a mosques and imams in the Islamic world and in the West to spread their version of Islam (appeasing religious critics of the corrupt royal family), as shown above Wahabbi mosques preach intolerance and terror. With the goal of bringing the whole world under their religious sway[98].

Wahabbist sentiment actually seems strongest among their upper class not the Saudi masses (the 9/11 hijackers were all "of good family"). However the masses of the Saudi people (and Shiites in the countries Eastern oil region along with the large population of foreign workers) despise the corruption and decadence of the Saudi royal family. This makes the Saudi regime heavily dependent on Wahabbist support to stay in power. It also serves the interest of the royal family to blame the West for the countries problems as it takes the focus off of the royal family.

In the short term the Saudi Royal family for better or worse looks secure. Al Qaeda terrorist attacks on the local population will likely only alienate public opinion in the Saudi Kingdom. And the withdrawal of US troops following the Iraq war will alleviate Muslim anger in the region (and since Iraq was taken over before hand without the appearance of weakness), if not towards the West at least towards the royal family. In the wake of the domestic attacks within Saudi Arabia the Royal Family will also be more likely to act to shut off the financial spigot to terrorist (mainly assumed to run through Islamic charities which operate abroad). Whether this will hold in the long term is another question.

Worse for the rest of the world, Saudi Arabia with its unused pumping capacity essentially dominates OPEC the way DeBeers dominates the diamond market[99], the Saudis can threaten to flood the market with cheap oil to bring other producers in line with their commands. They never do any more then threaten but the fact that they have the capability means other OPEC nations defer to them.

As my snippet above states, the dependence of the civilized world upon Saudi oil looks only to increase in the future without alternatives to oil being put on the market. Chinese demand will skyrocket as its economy modernizes and with 1 billion consumers world oil consumption may double in a couple of the decades. India will likewise begin to consume more oil. Energy independence will at that shift from a mainly economic issue to a crucial question of national security.

The Saudis, who as mentioned above dominate the OPEC cartel, will of course seek to keep prices from skyrocketing suddenly as that tends to encourage energy independence[99]. As demand grows OPEC and Saudi will seek to gradually lift prices. Russia will likely become more amenable to cooperating with OPEC as the rest of its economy develops and the benefits of restricting oil production become higher with increasing world demand.

Iraq

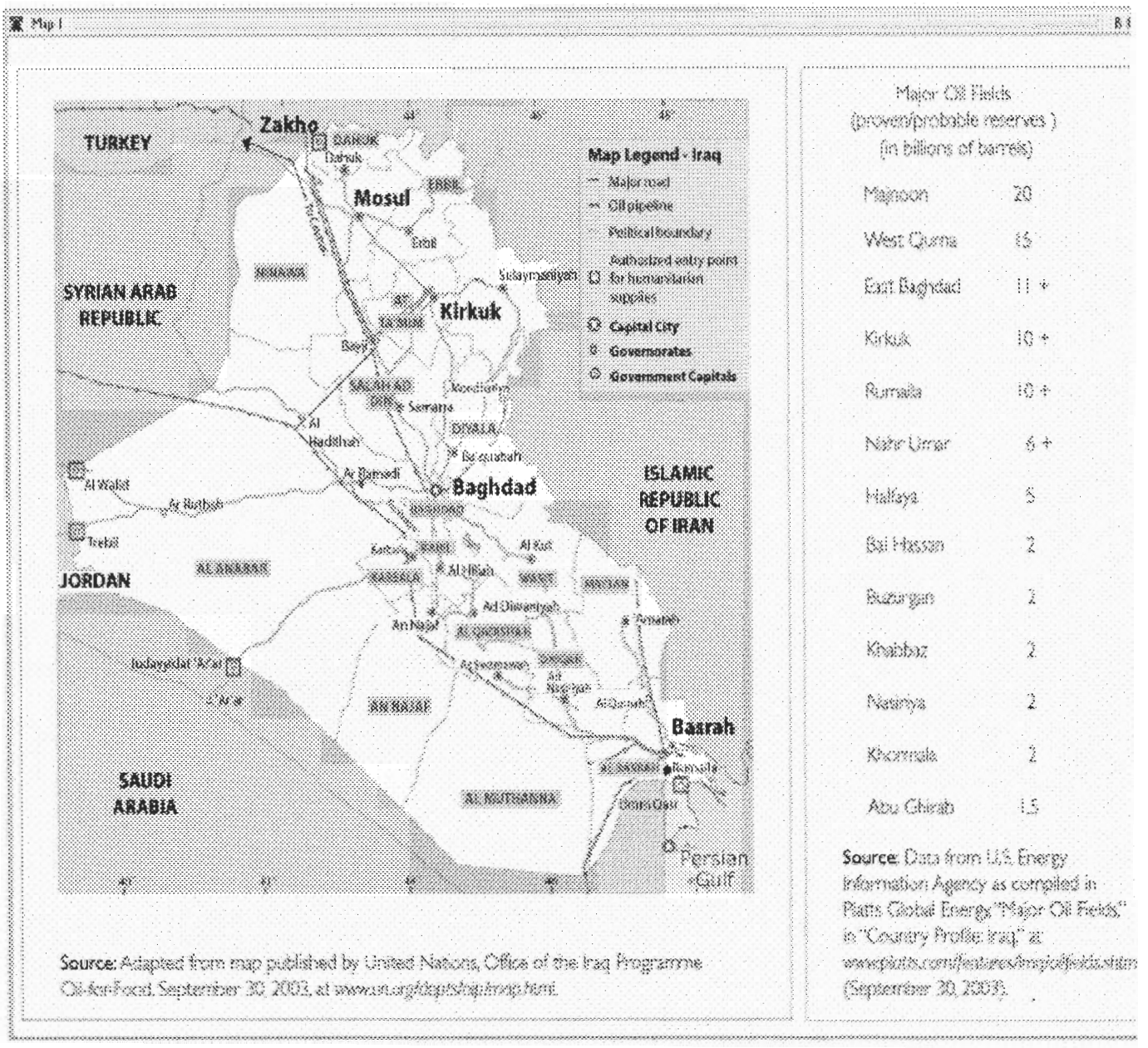

Figure 3-3: Major Iraqi Oil Fields & Infrastructure[31]

The above figure shows existing Iraqi pipeline routes and known areas with major oilfields.

Iraq has 120 billion barrels of proven reserves[28], second only to Saudi Arabia. The actual number could be much higher as in contrast to the rest of the Middle East only 10% of the country has been explored[28]. Its current oil production due to its colorful recent history, as a result of which very almost no new infrastructure has been built since the 1st gulf war and its existing infrastructure has not been maintained, is only 1.5 million barrels per day.

The cost of extraction for Iraqi crude ranges from 1-3$ per barrel[29] very cheap compared to non Middle Eastern producers and comparable with Saudi Arabia's cost. As mentioned above its oil infrastructure is badly damaged due to both Gulf wars, the Iran-Iraq war, and the sanctions following the 1st gulf war. Efforts to repair the infrastructure faces sabotage now by the Iraqi insurgency. Iraq is mostly landlocked and most oil must be piped to the port of Basra for export, thus making shipments of Iraqi oil run predominantly along one easily sabotaged route. Even repairing the infrastructure and protecting it from sabotage could significantly increase production. Other pipelines go to Turkey for export. With the insurgency worsening in the short term sabotage will likely continue to remain a problem.

Geopolitical Situation and the War

The resistance has presented difficulties with restoring oil production. Oil Pipelines are routinely bombed both by Baathist and Islamist terrorist in the South and

Kurdish nationalist and Marxist terrorist in the North. Saddam's recent capture will demoralize the substantial Baathist elements of the resistance in the so called "Sunni Triangle" especially around his hometown of Tikrit. But more dangerous Islamic fundamentalist may fill the void.

The future of Iraq is uncertain, while the task of keeping order within the cities can be delegated to sepoys. Protecting the oil infrastructure and insuring a Westernizing regime will likely require American troops to stay in fortified hilltop bases for many years. During this period policy must remain fairly consistent despite the shifting winds of American electoral politics.

Because Both Kerry and Bush support staying in Iraq[121] that means that for now we don't have to worry about an anti American fundamentalist regime coming to power in the near term. However failure to stop the daily American causality reports will eventually wear down public support for the occupation. Morale among military reservist is low[122], as a consequence enlistment rates may decline, thinning the ranks of the army and perhaps necessitating a withdrawal, a draft is not something American public opinion will likely tolerate.

Iraq Capacity and OPEC

If America truly manages to establish a stable puppet regime in Iraq, then the country would likely withdraw from the OPEC cartel and thus counterweight Saudi Arabia. If Iraq allows multinationals a greater role and the security situation stabilizes production could increase dramatically. In the short term Iraq cannot boost its supply levels as its capacity is limited by its damaged neglected and undeveloped infrastructure. In the long term, like Saudi Arabia, Iraq has the prospect of strongly boosting its

production levels provided things stabilize and remain that way. Iraq's future oil production probably depends more on this point then any other.

Future Scenarios for Iraqi Oil Production

Given the volatile political situation in Iraq, the extreme uncertainty about its political future, the dismal state of its current oil infrastructure, and the fact that it has not been thoroughly surveyed, getting hard numbers for future oil production is impossible and any estimates are likely to be far off, predicting the future is difficult enough but there are too many dynamic variables, too many X factors, and too many unknowns. Extremely rough estimates based on certain defined political and economic scenarios can however be forecast.

Optimistically in the long term Iraq may be able to increase its oil production by 10-15 million barrels of oil per day by 2020 if reserves are aggressively sough out and infrastructure for oil is aggressively developed. This scenario would require Iraq to be given a stable Westernizing regime by the US and probably also require a withdrawal from OPEC with the countries oil sector being fully opened up to Western oil companies.

Realistically given that only 10% of the country has been surveyed, its abundant and underutilized proven reserves, it should at least be able to reach the current capacity of Saudi Arabia and produce 10.5 million barrels of oil per day in 10 years and more then that in 2020 if the US can stabilize the country and stop sabotage.

Pessimistically sabotage will continue to be a problem perhaps forcing a US withdrawal followed by anti western, anti American, Islamic regime coming to power or the country splitting up into warring factions along ethnic and religious lines. In this case

Iraqi oil production will not increase much at all for a long time even with increased worldwide oil demand.

Figure 3-4 shows curves of possible future Iraqi oil production based on various scenarios outlined below and detailed more in Appendix A.

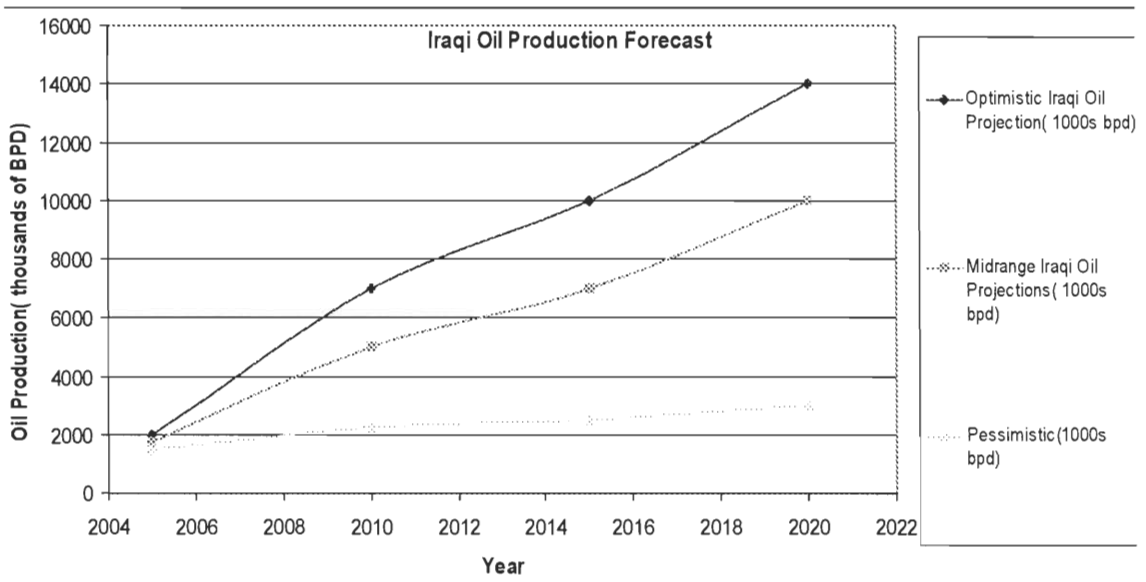

Figure 3-4: Scenarios For Future Iraqi Oil Production

The gap between the Midrange and the Pessimistic projections is so stark because the pessimistic projection is the scenario where Iraqi production doesn't rise much at all over its current meager level due to continuing political turmoil which precludes any meaningful repair of its existing infrastructure. The Optimistic projection is a rough assessment of Iraqi potential if it withdrew from OPEC, and infrastructure and oil exploration was energetically pursued in a much more stable country.

Optimistic Curve- Assumes that Iraq will stabilize and that infrastructure willbe aggressively developed to exploit the countries oil reserves, so that by 2020 it well exceeded Saudi Arabia's current production. Also assumes a withdrawal from OPEC.

The initial large upslope on the curve is due to the fact that production can increase substantially merely via repairing existing infrastructure.

Midrange Curve- Assumed that Iraq will stabilize and that by 2020 Iraq's supply capacity will reach that of about what Saudi Arabia has currently. As with the previous curve the large upslope is based on the assumption that production can increase significantly merely via repairing existing infrastructure.

Pessimistic Curve- Assumes continuing instability will prevent any real increases in production over current levels even as prices rise.

The Rest of the Middle East

Comparative Oil Reserves in Billions of Barrels

Country	Identified	Undiscovered	Identified + Undiscovered	Proven	% of World Total
Bahrain	-	-	-	.2	(<0.05%)
Iran	69.2	19.0	88.2	89.7	8.6%
Iraq	98.8	35.0	125.8	112.5	10.8%
Kuwait	92.6	3.0	95.6	96.5	9.2%
Oman	-	-	-	5.5	0.5%
Qatar	3.9	0	3.9	13.2	1.3%
Saudi Arabia	265.5	51.0	316.5	261.7	25.0%
UAE	61.1	4.2	65.3	97.8	9.3%
Total	583.0	112.2	695.2	677.1	64.7%

Table 3-1: Middle Eastern Oil Reserves by Country[123]

The above table shows the oil reserves of each Middle Eastern Country.

The region in total is estimated to have about 700 billion reserves of oil. Production cost are generally cheaper then the rest of the world. However the short term capacity to increase production for OPEC total is only estimated at 3 million barrels per day[33] with Saudi Arabia accounting for two million the rest only have a million barrel

per day short term capacity. Furthermore long term increases in smaller Gulf States such as Kuwait Bahrain and Qatar are unlikely as they have been thoroughly explored. Thus any long term improvements in production capacity in the Middle East will mostly have to come from Iraq and Saudi Arabia.

Russian and the Caspian

Summary of Region

Russia proper according to Yukos has about 100 billion barrels of oil[35]. The Caspian has proven reserves of around 30 billion barrels but is estimated to hold as much 200 billion[36] but this is most likely wishful thinking[124]. Russia proper, given its size, and given the fact that under communism it probably was throughly explored for oil there is a strong possibility there are large reserves of undiscovered oil.

Infrastructure and Caspian Oil

The main problem with Caspian oil is building an outlet for it to its main markets in Europe and the US. There are existing pipelines the Baku-Novorossiisk[38] pipeline carries oil from Baku to the black sea, but the pipeline runs through Chechneya and has been subject to sabotage. Another pipeline runs from Baku to Susa through Georgia[42] which also takes oil to the black sea. These pipelines apparently lack the capacity to move all the oil which potentially could be produced in the region, and the resulting transportation bottleneck limits oil exports(and consequently new drilling). The bottleneck of export infrastructure has caused Caspian oil development to suffer as it makes it extremely expensive to get to market and in terms of cost its not currently very competitive with Middle Eastern oil.

According to the EIA the Caspian region is current producing 1.45 million barrels of oil per day[39], it may be able to produce 1 or 2 million more per day long term according to figure 3-4. Russia is currently producing near capacity at 6.8 million barrels

per day[40]. Russia also seemingly wants to gain market share and has not been eager to participate in OPEC cutbacks of oil production[41].

Pipelines and the Future of Caspian Oil Production

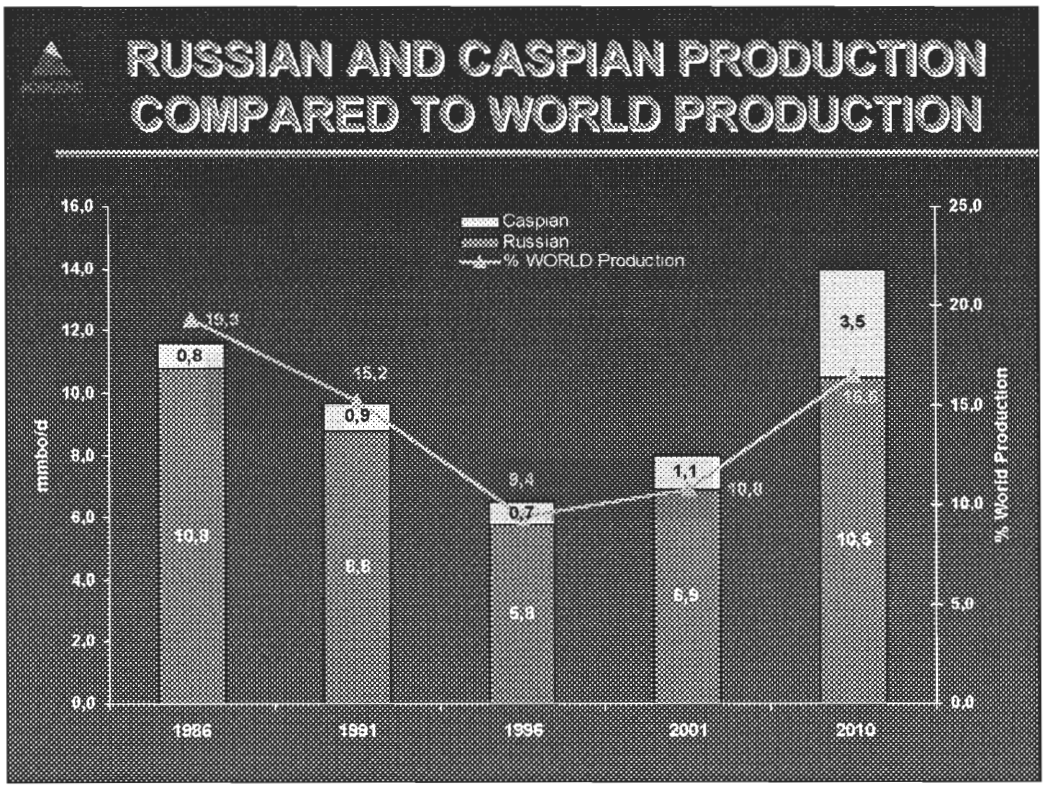

Figure 3-5: Russian and Caspian oil production past present and future [50]

The graph shows a projection for future oil production in Russia and the Caspian up to 2010.

The somewhat pessimistic above projection of future Russian and Caspian oil production, given that exploration of the Caspian is disappointing and Russian oil production seems to have peaked at the current price level(there is more expensive Siberian oil which could be developed but that will happen AFTER price shocks, the

same applies to oil which Russia may have far inland, the capital in pipelines to bring that to market would be prohibitively expensive and take a very long amount of time to build) seems likely to occur with little deviation. Any variance in this projection would likely be small in significance to Middle Eastern and West African projections, as such it's not really important to forecast multiple scenarios.

Caspian Oil and Proposed Pipeline Routes

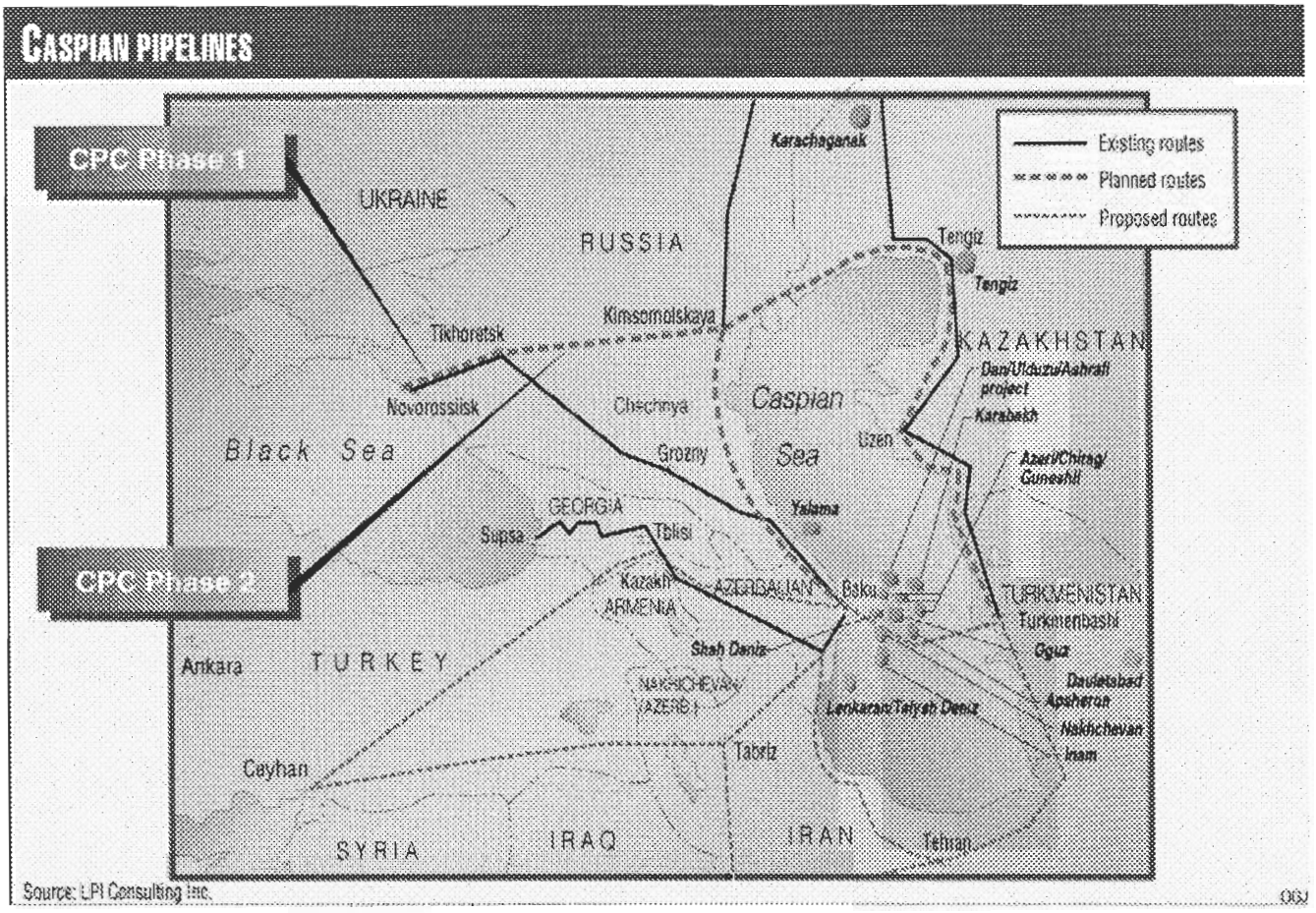

Figure 3-6: Existing Caspian Oil Pipelines and Proposed Pipeline Routes[42]

Figure 3-6 shows existing, planned, and proposed oil pipeline routes(the picture comes off someone's webpage at the University of Texas at Austin. Exactly what "CPC"

stands for is not explicitly defined. Upon examination it seems to refer to a planned pipeline route from Novorossiisk to a junction between planned routes from Baku and Turkmenistan) in the region around the Caspian sea.

To expand the production of Caspian Oil the pipeline infrastructure must be expanded. Proposed and planned routes for pipelines are depicted above.

Any pipeline must be secure against sabotage and any arrangement for their construction must satisfy the large oil conglomerates who put up the money, the local governments, other unstable countries the pipelines pass through, and be satisfactory to the Russians. The Russian government would obviously prefer pipelines run as close to their countries borders as possible and not through the southern Stans to Turkey which would cut them out. The West on the other hand does not want to be dependent on Russia and would prefer the routes that run through Southern Turkey. Despite all this Russia okayed the Baku-Ceyhan pipeline shortly after 9/11[43], it's expected to have a capacity to move 1 million barrels of oil a day[45]. This route may also be subject to sabotage by the Kurdish PKK as it runs through the Kurdish region of Turkey.

Analysis of Economic Role of Caspian Oil in the Future

The average price of extraction of Caspian oil is over 5$ a barrel in most of the region plus the export cost[49]. Thus Caspian oil is only competitive with Middle Eastern oil at high prices. As oil prices rise Caspian oil will become more important and

more viable but it is unlikely that Caspian production can increase significantly to meet world demand.

Given the high cost of production in the Caspian and its uncertain Byzantine pipeline politics it's uncertain whether Caspian oil will really become competitive with Middle Eastern oil in the near future. After a dramatic increase in oil prices more extensive infrastructure may be developed but the area likely won't be significant even then compared to other producers.

Africa

Africa holds proven oil reserves of between 52 and 75 billion barrels as of 1999 ([52], [53]). There are probably far more as Africa has been less thoroughly explored for oil then most of the world. Current Oil Production in non Arabic non Muslim non OPEC West Africa stands at 3.4 million barrels per day. Oil production in North Africa will likely remain flat or perhaps decline a small amount in the future despite rising demand as that region has been thoroughly explored and with the exception of Libya continuously developed. So the focus of this subchapter will be upon West Africa as only that region is likely to increase production to meet rising demand.

Africa's oil infrastructure is generally very poor outside of North Africa and Nigeria. There is little refining capacity and pipeline capacity to bring oil inland is limited. A new pipeline to the landlocked republic of Chad has opened recently if commercially successfully it could spur further infrastructure development[55] especially given recent high oil prices.

Due to Africa's size and diversity the price of oil extraction can vary dramatically. In Sub Saharan Africa it is generally higher then in the Middle East and North Africa and the cost of getting oil to market is also generally higher due aforementioned poor infrastructure.

Long term Production Capacity and Future Production Forecast

West Africa has no short term capability to increase production but in the long term with exploration and development it could be possible to production could be increased significantly. Hard numbers are once again given Africa's size and the fact it hasn't been thoroughly surveyed are hard to predict and very rough estimates must be made. Conservatively African oil production could be increased about 5 million barrels of oil per day by and optimistically by about 10 million by 2020(the US including Alaska produces about 8 million bpd with about ¼ the reserves, [67]). Given rising demand and the fact that Africa has not been thoroughly surveyed, that its political problems tend to be highly localized, and that its infrastructure is underdeveloped an overly pessimistic scenario of declining oil production or even one where production holds steady despite rising demand isn't overly realistic. West African oil production has nowhere to go but up.

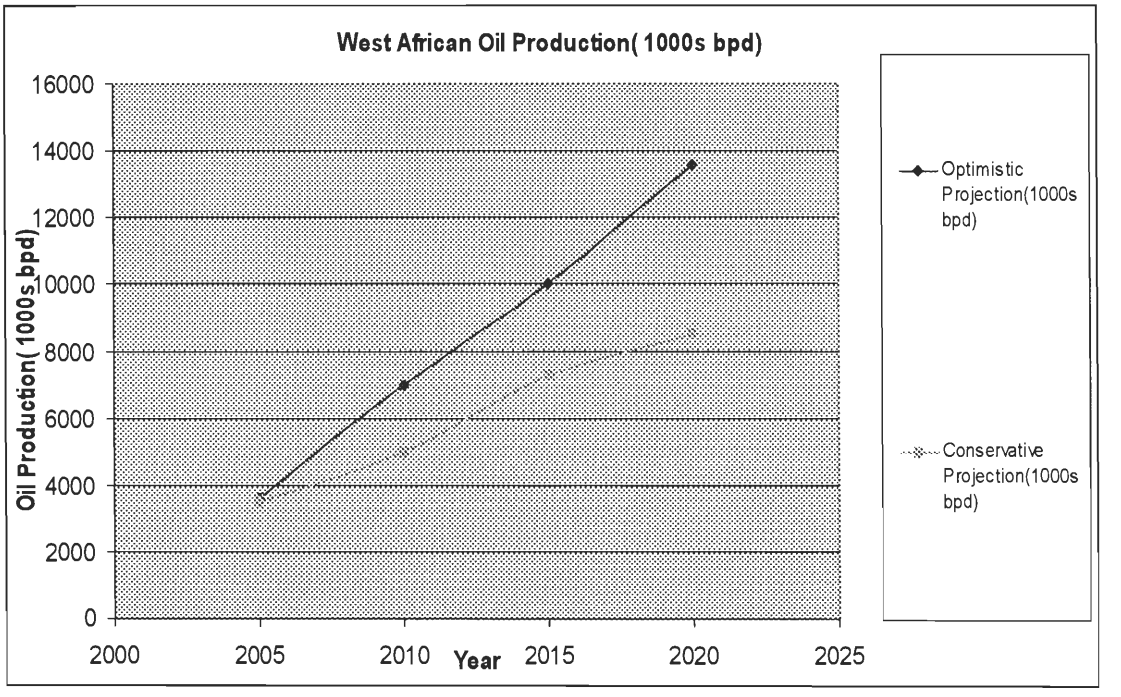

Figure 3-7: Future African Oil Production Scenarios

The above figure has two possible scenarios of future West African Oil production an optimistic and a conservative projection. Given the uncertain African oil reserves and the immaturity of its oil industry this was strictly guesswork based upon the above analysis of African reserves versus US reserves and its undeveloped infrastructure combined with political docility. In an optimistic scenario this will likely be developed as fast as possible at a near constant rate of expansion until production peaks(which in West Africa likely won't be till after the world economy has been weaned off oil).

Possible Scenarios for future net production Increases of Saudi Arabia, Iraq, West Africa and the Caspian

Based on the above scenarios for oil production in the 4 individual regions above (Iraq, Saudi Arabia, West Africa and the Caspian) scenarios for net oil production increases can be extrapolated. In looking at the above 4 regions scenarios of future oil production for each were forecast. 4 forecast were made for Saudi Arabia, 3 for Iraq, 2 for Western Sub-Saharan Africa and only one for the Caspian (due to its limited possible output). This makes for 24 possible permutations of future oil production for those regions. Only 6 will be considered here.

Figure 3-6 was formed by taking the **summation** of various permutations of forecasted production of the 4 regions considered above and subtracting the current production to forecast possible scenarios for how much future oil production will **increase** over its current levels.

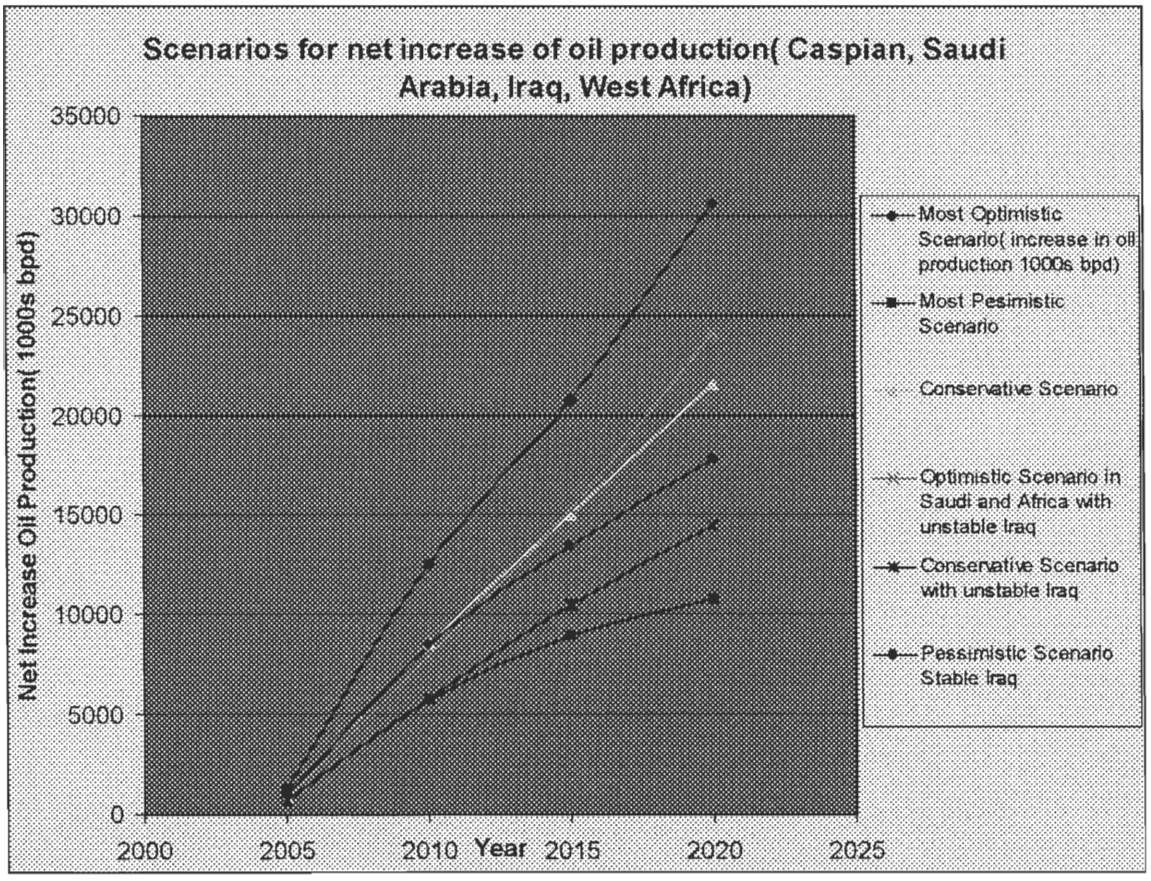

Figure 3-8: Cumulative Scenarios For the Increase in world oil production between now and 2020

Explanation of Projected Scenarios

Optimistic Scenario- This line represents the projected future increase in oil production based on the **summation** of the most optimistic projections for the 4 regions.

Pessimistic Scenario- This line represents the projected future increase in oil production based on the **summation** of the most pessimistic projections for the 4 regions

Conservative Scenario- This line represents the projected future increase in oil production based on the **summation** of the midrange Saudi & Iraqi projections, the conservative African figure and the one Caspian projection.

Optimistic Scenario in Saudi Arabia and Africa with Unstable Iraq- This line represents the projected future based on the **summation** of the optimistic Saudi projection, the optimistic African projection, the one Caspian projection, and the pessimistic Iraqi projection.

Conservative Scenario with Unstable Iraq- This line represents the projected future increase in oil production based on the **summation** of the midrange Saudi projection, the conservative African projection, the one Caspian projection and the pessimistic Iraqi projection.

Pessimistic Scenario With Stable Iraq- This line represents the projected future increase in oil production based on the **summation** of the most pessimistic projections for Saudi and Africa, the Caspian projection, and the midrange Iraqi projection.

The Rest of the World, Flat Production and the Hubbert Projection

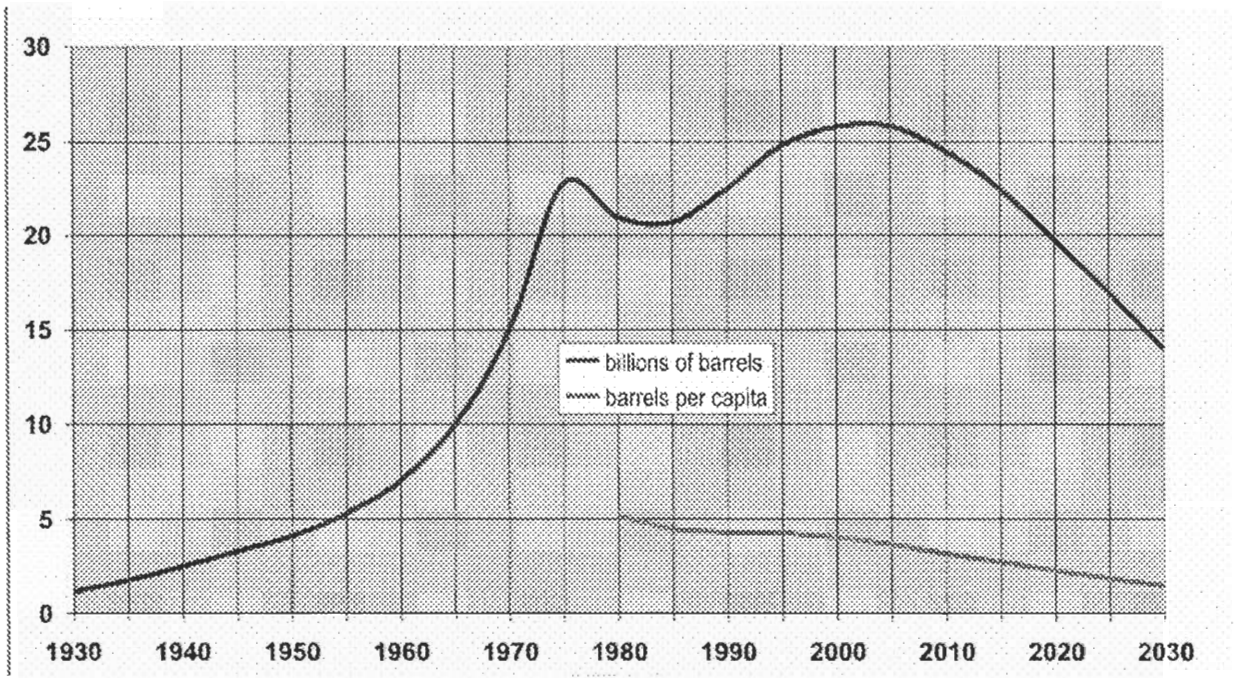

Figure 3-9: Hubbert Curve of World Oil Production(in billions of barrels per year)[74]

Figure 3-9 shows the Hubbert projection of world oil production up to 2030. It predicts a peak in world oil production about a year from now in 2005.

Predicting overall future world oil production is difficult. There is much controversy in this field, nobody has perfect information and involves numerous dynamic variables. Many before had predicted catastrophic declines in oil production around set dates[125]. The main question of interest economically is not when the world will begin to run out of oil, rather the main question is when the production of conventional oil will peak (because even given flat demand in this scenario prices will rise catastrophically after this point) According to the so called Hubbert projection's[56] "cheap" oil

production should peak in at the latest about 10 years from now. The methodology of Hubbert is cited in reference[57].

Because of past Chicken Littles this kind of alarmism raises suspicion and one may even think they may encouraged by the oil companies to maintain prices. However the writers own numbers about world capacity for increased oil production only projects a possible increase production of about 30 million barrels per day by 2020 and that doesn't take into account possible declines in production elsewhere in the world. World demand, on the other hand, is projected to increase by 30-45 million barrels per day. If this scenario holds energy cost, particularly in the transportation sector will skyrocket even if demand remains flat.

The potential crisis in terms of price and supply will be more or less severe depending on who you believe. The oil company geologist and the followers of the geologist Hubbert (who accurately predicted the decline in US oil production [56] within one year) claim that many countries have artificially inflated their actual oil reserves[59], especially in the Middle East and ex communist countries (which would effect the main potential source of possible increasing oil production outside West Africa and the Caspian). While on the other side certain economists have challenged this view as alarmist [60]. If the so called Hubbert peak of world production does happen an era of supply shocks and oil price shocks will ensue, even if oil demand remains flat. If oil demand exceeds supply the price of oil will increase either till more expensive sources fill the supply shortfall or some of the oil demand is priced out of the market.

Summary of Data in Favor of Hubbert

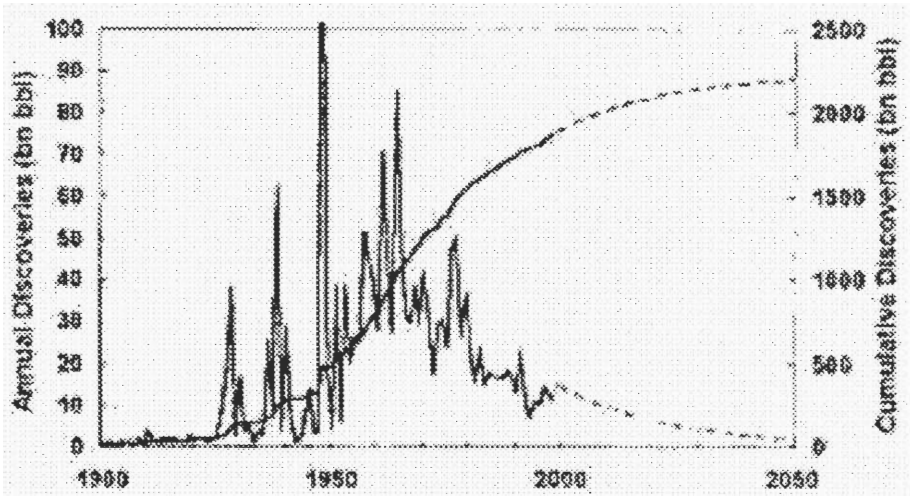

Figure 3-10: Oil Discovery by year and cumulative discoveries up to 1999[70]

The data in favor of Hubbert and the oil geologist who concur with him is summarized as follows.

Figure 3-10 shows annual oil discoveries (in billions of barrels) which generally trended upward till about the mid 1960's, and have since trended downward(the line which moves upward till it gradually levels off are cumulative discoveries). The dotted lines are extrapolations based upon the trend in oil discoveries.

Even given the historical oil discoveries shown in the 90's, figure 3-10 shows the oil companies are not discovering enough new oil fields to keep up with growth in consumption [58] or even current depletion of existing reserves.

The Hubbert geologist think (I must stress that shale and artic oil is as yet untapped, there is more oil available but its much more expensive to extract) that the world has been thoroughly surveyed for oil (I must stress that shale and artic oil is as yet untapped, there is more oil available but its much more expensive to extract, West Africa and Iraq are notable exceptions as they haven't been thoroughly explored). They say that bigger more productive oil fields tend to be discovered 1st and any undiscovered oil fields are also not very big. The oil company geologist(though once again we must consider the source, the oil company geologist though in the best position to know about future oil production, but their bosses do not want to encourage too much optimism about future oil supplies as that would not bring down prices) are not optimistic about this changing in the future. So via the Hubbert methodology there is no projected growth in "cheap" or "conventional" oil reserves to keep up with increased Asian demand.

Economics vs. Geology and Hubbert

This does not mean that world production will peak. Given Saudi Arabia's, West Africa's, and Iraq's untapped long term potential to produce more oil at conventional price levels oil production is unlikely to peak anytime soon unless production very rapidly declines in the rest of the world. Even if you accept the most pessimistic pro-Hubbert geologist predictions that oil reserves in the Middle East have been artificially inflated they still don't produce the amount of oil in proportion to their reserves the United States does. At worst, the dismal rate of new oil discovery will just mean that higher cost oil field that have not yet been tapped will enter the market as oil prices rise to the point where oil production in those fields has a level of profitably (even in terms of

strictly conventional oil) Oil production now is not at long term world capacity because some oil has a higher cost of extraction (and refining due to impurities) then others as well as lack of development in some oil rich trouble spots. As such a true peak in oil production is unlikely in the near term.

Oil production in regions not mentioned earlier in the chapter however is likely to remain mostly flat with possible insignificant increases or decreases in world production (Canada is a possible exception given a suspicious recent huge increase in its possible oil reserves, but that is very much a question of who you believe and given that Canada has a mature oil industry and this is a huge recent seemingly implausible jump in reserve estimates with little justification the writer is inclined to be very skeptical,[110]) . Outside of Russia, Africa and certain parts of the Middle East the oil industry is truly mature, oil is produced as fast as it can be drilled. And the land and surrounding ocean has been thoroughly surveyed making major new finds unlikely. There is some limited long term capacity to increase oil production at existing price levels by drilling for oil in land heretofore kept off limits to oil drilling by environmentalist. But it's unlikely the world capacity of such fields could keep pace with decline in existing production.

Summary of Why a Hubbert Supply Side Disaster is unlikely

As for the foreseeable future world conventional oil production (at current price levels) in most regions of the world, will at worst likely remain flat and possibly increase somewhat. The Middle East is not likely to have its production fall anytime soon(except through a political catastrophe). The United States produces almost as much oil per day as Saudi Arabia, even though the United States has far less oil reserves. West African oil

production has nowhere to go but up. Iraq has not been thoroughly surveyed and if any political stability can be achieved for a decent length of time production will quickly rise. Thus conventional oil production even at the current price level (which the demand side will drive up anyway bringing more oil into play) has not yet peaked and probably won't for the foreseeable future.

Summary and Analysis of Overall World Oil Supply Present and Future

Given the poor rate of discovery of new fields in other regions of the world then those mentioned above, and their relatively mature oil industries with infrastructure more thoroughly developed to exploit their oil. The production of oil in the rest of the world, without a dramatic increase in prices (to make more expensive field more economically viable) will likely remain flat if not decrease. For the purposes of economic analysis done in the following chapter, a relatively flat oil production in the rest of the world was assumed.

The regions of Saudi Arabia, Iraq, West Africa and the Caspian all have the long term ability to increase their oil production (at the current price levels) to keep up somewhat with rising demand. However, only in the most optimistic projection above (for the net increase in oil production for the 4 regions) does oil production increase to keep up with the low end estimate of the projected increase in demand by 2020. Even in that scenario prices will rise as the world oil market will be working at capacity, any cutbacks by OPEC will be devastating as anything short of all oil produces working at

capacity will lead to a supply shortfall on the world market. And while high oil prices will probably slow economic growth and halt further increases in demand after 2020 production levels will likely fall off somewhat after that point.

West Africa and the Caspian will almost certainly increase their oil production by at least 7 million barrels per day by 2020. Large increases in the oil production of Iraq and Saudi Arabia are more uncertain and heavily dependent on questionable geopolitical factors.

Thus while a peak in world oil production is unlikely anytime soon capacity to increase oil supply at existing crude price levels is limited and given projections in raising demand is unlikely to keep up.

Chapter 4: Supply-Demand Interaction, Rising Prices and Economic Consequences

Projections of Gaps between Supply and Demand

As established in chapter 2 the demand for oil in 2020 will fall at the low end at about 105 million barrels per day and at the high end at 120 million. As such they present two possible demand scenarios. These can act as columns in a table in forecasting the gap between supply and demand.

The following table gives the increase in world oil production in 2020 based on the 6 oil production scenario forecast determined in Chapter 3.

Oil Production Scenarios from chapter 3	Increase in Oil Production Millions of bpd by 2020
Optimistic Projection	30.6
Pessimistic Scenario	10.8
Conservative Scenario	21.5
Optimistic Scenario with Unstable Iraq	24.1
Conservative Scenario with Unstable Iraq	14.5
Pessimistic Scenario but stable Iraq	17.801

Table 4-1: Possible Increases in world oil production by 2020 in the regions of Saudi Arabia, Iraq, the Caspian Sea and West Africa

Using these numbers plus the current world oil production of 75 million bpd (adding 5 million bpd from Canada, Russia, Venezuela and other producers not to be too pessimistic) scenarios for the future gaps between world oil supply capacity and oil demand can be determined.

Oil Supply Scenarios Production in 2020(millions of bpd)	Supply Gap in Millions of bpd if demand for oil is 105 million bpd	Supply Gap in Millions of bpd if demand for oil is 120 million bpd
Optimistic Scenario	5.600	-9.400
Pessimistic Scenario	-14.2	-29.2
Conservative Scenario	-3.500	-18.500
Optimistic Scenario but unstable Iraq	-.900	-15.900
Conservative scenario with Unstable Iraq	-10.5	-25.5
Pessimistic Scenario except Iraq is stable	-7.2	-22.2

Table 4-2: Projected Gaps Between Supply and Demand

So in the most optimistic scenario total world capacity for oil production at roughly the current price levels only exceeds world demand by 5.6 million barrels and in the most pessimistic scenario it lags by 29.2 million.

Supply Shortfalls and Oil Prices in the Short and "Short Long Term"

In the event of a supply shortfall prices will always rise in the short term. Predicting the actual equilibrium value the price of oil will stabilize at involves numerous dynamic variables and would require perfect information which is impossible to achieve. It is possible to get a short term lower limit projection of the maximum possible price based on historical scenarios. In the late 70s and early 80s the price of oil rose to roughly eighty dollars a barrel, sixty dollars when indexed to inflation for the year 2000 **when there was no real such shortfall between oil supply and demand**[18]**.**

So at a minimum, in the event of a real shortfall oil prices will likely rise to at least sixty a barrel in the short term, and oil prices have already hit a 13 year high of fourty dollars per barrel. The short term price in the event of such a shortfall will be the price at which enough oil buyers are priced out of the market until demand falls. The price will in all likelihood rise above 60$ per barrel but how the price of oil will rise above that in the short term is not possible to guess in any scientific way. It is a theorem of both chaos theory and empirical data that short term commodity prices are unpredictable, including with any mathematical models even those based upon historical data(of which there is none for a true shortfall in world oil capacity vs. demand) [96]. It can only be determined that the price of oil in the event of a real shortfall will go up dramatically in the short term. It can simply be stated that the price will rise until enough direct or indirect consumers of oil cannot (given oil is essentially a necessity in many cases the sky will be the limit) afford to pay for it any more. There is some elasticity in the demand in that some oil consumers will choose to take the train, ride bicycles, travel less etc but that won't account for the entire short term gap in capacity, but much of the gap in short term demand will manifest itself in the form of human misery unprecedented

in modern times as the world's poor being unable to afford food or afford any products necessary or not imported outside their local area necessary for survival or not, high oil prices will also trigger inflation . Given the indispensability of oil, taking into account that the short term price of a commodity cannot be predicted with any accuracy especially in a historically unprecedented situation where there is a supply shortfall in a commodity which globally has a mostly inelastic demand. Taking a guess "a priori" a price of 80-100 a barrel is not unreasonable before demand falls back down to the level of supply.

Much of the commercial fertilizer today is Petroleum based and farm machinery is also fuel intensive. Most of the world's (non subsistence) food production comes from a few huge mechanized and thus oil dependent commercial farms. It has indeed been said that "agriculture is a process by which we use soil to convert petroleum into food"[60]. Food production actually conforms to a Pareto distribution where 20% of farms produce 80% of the world's food[62]. While skyrocketing oil prices in such a scenario may make the Amish very rich it will mean mass starvation for the worlds poor and a larger percentage of the budget of those better off going to food and other basic necessities. Thus it is conceivable that one mechanism via which demand will be brought into line with supply is that of starvation. Thus the most like way oil supply and demand will be brought into line is via Malthusian catastrophe. As 3rd world consumers are often on the edge of subsistence already today. The prices may rise to the point where much of the 3rd world population even with aid cannot afford food and will die of starvation. Since most countries are also net food importers (luckily not the United States) the high transportation cost will also negatively affect them.

Because of the limited ability of 3rd world consumers to pay for the high food cost driven by oil prices over 100$ a barrel are unlikely (unless the short term supply shortfall is concurrent with a disruption in a principle oil supplier). Thus a rough "a priori" estimate of an upper limit can be established.

In the "short long term" (a time period dictated by however long it takes to build infrastructure for producing oil via non conventional means after a dramatic price spike above 40$ dollars a barrel) the price of oil is determined by the current cost of alternatives to "conventional" oil. These alternatives are namely coal liquefaction and shale oil production. These methods will not be used on a large scale till the price **stabilizes** above their cost of production (though research into making them cheaper will be pursued at a lower oil price) as the infrastructure to produce fuel via these methods is expensive and there is no hope of a return except at a price above their cost of production which currently stands around 35-40$ per barrel (the current price of oil as of May 2004) ([81], [84]). Before it hits the world fuel market this is marked up a certain amount of course so the producers make a profit. While this is comparable with current oil prices with the Saudis pledging to increase production and with yet no capacity shortfall oil prices will likely fall slightly in the near future. Since that means oil prices have not yet stabilized above 40$ per barrel it can be concluded that groundwork for larges scale coal liquefaction and shale oil production will not likely start soon. But in the event of a real supply shortfall in conventional oil production after a huge spike the prices will stabilize

slight above the cost of producing oil via these substitute processes, which will also likely decline in price as they become a more indispensable part of the energy market.

Socioeconomic Impact of High Oil Price Upon the United States

The conventional formula which relates the price of a gallon of unleaded gas in the US to the price of crude is that for every dollar increase in the cost per barrel of crude oil the price of a gallon of gasoline increase by about 2.5 cents[104] with some lag in adjustment between gasoline prices and crude oil. At 100$ per barrel (the upper range of a short term price) that means the crude oil cost per gallon of gasoline will total 2.50$. At a cost of 50$ per barrel (the "short long term" cost of oil based upon the cost of production of Shale and Coal Liquefaction plus margin for oil produces) this falls to a 1.25$. The rest of the price comes from taxes, refinery margins, and dealer margins (the profit of the gas station, this item is insignificant to the overall price). While high crude prices have affected the cost of gasoline a bigger factor currently are the lack of US refining capacity (no new oil refineries have been built in 20 years [105]) and the Balkanization of local US gasoline requirements due to a hodgepodge of state and municipal regulations on gasoline [105]. If the refinery situation is not addressed, gasoline and other petrochemical products will go up in price simply due to a lack of refining capacity able to meet demand. Oil refineries also require maintenance and US refineries cannot long sustain working at 95% of capacity. More refinery capacity will also be needed if Coal Liquefaction or Shale is to be used. Despite high oil prices, tight capacity, and a US administration (with a Republican congress) amenable to the oil

industry and cool to the type of environmental activist who would oppose refinery construction that still hasn't happened. This can mean one of two things.

1. **Pessimistically, That the Environmentalist and NIMBY (Not In My Backyard) lobby, is too powerful in America today to be opposed and that this will continue until energy prices reach catastrophic levels.**

2. **Optimistically it means the Oil Industry has long been preparing for a transition to an alternate energy source and does not want to invest in building new oil refineries (there is some evidence for this see[106]).**

But regardless the combination of lack of US refinery capacity and permanent high crude oil prices will mean very high gas prices in the future **that will not go away**. Neither new oil infrastructure nor the infrastructure or technology to support alternatives can be developed overnight. In Vietnam currently a large scale modern oil refinery has a 4 year construction schedule[109].

Economically this period of high gas and petrochemical prices (due to both supply shortfalls and lack of refinery capacity) will severely hurt the United States and probably lower its standard of living. High gasoline and jet fuel prices will drive up the cost of every finished good and every raw good not produced in the local area. United States consumers will travel and spend less to save on fuel cost, world trade outside of the oil sector will slow severely due to similar effects upon other economies, while the one silver lining in declining trade volumes for the US its trade deficit will not fall and will likely increase because the principle component of the US trade deficit has long

been its oil imports. The principle oil exporting economies in the Middle East lack the population numbers to pick up the slack in US imports.

High oil prices also tend to cause inflation despite decreased economic activity which either causes devaluation in currency or higher interest rates.

As such the US economy will be laboring under an economy with low or negative growth with either declining currency values or high interest rates at a time when a large % of the large American "Baby Boom" generation will want to collect social security(something financially unsustainable in and of itself in the writers opinion and Alan Greenspan's[111]). Taken together these factors would inevitably mean a period of horrible economic misery in the US. True famine in the US would be unlikely but trying to pay for an unsustainable compulsory pyramid scheme that already consumes most of the Federal Budget in the US with the tax dollars of younger workers who will never see a dime back in a time of "stagflation" worse then the 1970s will produce economic misery never seen in the US and the best analogy is perhaps the German Weimar Republic after the Depression. It is not at all unreasonable to suggest that a bankrupt US government run by venal politicians who will want to rob younger workers in tough economic times to win reelection of social security and Medicare recipients will endure as the younger generation could plausibly decide in overwhelming numbers that their interest are better served by a more authoritarian government who's leaders not depend upon the votes of people the government pays with tax money stolen from them and promises more decisive action to resolve economic problems.

Long Term Prices and Alternatives to Oil

In the long term oil prices above 40$ per barrel and likely supply capacity shortages will signal the end of oil as the world's primary source of energy in any economic sector and serious development of alternative energy. Serious exploration of alternatives to petroleum, to the extent it hasn't begun already will certainly begin in the event of a true oil supply shortfall. A true energy shortfall, especially one causing a severe economic crisis would in addition to making research into oil alternatives attractive to private industry; the crisis would finally force the topic to become a priority for the venal politicians and the fickle Western press. Since Environmentalist would have far less clout after an oil crunch oil use would be quickly and totally removed from those sectors in the energy market where it has substitutes, most significantly heating and electricity generation to be replaced either by renewable energy sources, new nuclear plants, or other hydrocarbons in particular coal.

In the transportation sector however things would be more problematic. Cars and trucks can't run directly off renewable sources, batteries are impractical, nuclear power plants are obviously out of the question. Non conventional oil will likely be the 1st thing brought to market to serve existing internal combustion engine cars which run off gasoline. But worldwide there would be a big technological push to find an alternative to the internal combustion engine. The seeming consensus based on the preponderance of

references below for an alternative fuel would be hydrogen. The oil shock would bring the automobile, oil and energy industry, and gradually the retail gas market together to solve the "Chicken and Egg" problem(i.e. car companies won't build a hydrogen car until there is a distribution network for fuel and gas stations won't carry hydrogen until there is a demand for it in the form of a car. Liquid Hydrogen has the benefit of being a much higher energy density then gasoline, however given its **mass density** it requires a tank of 3 times the volume of a gasoline tank to provide an equivalent amount of energy[103]. Also to power a car off hydrogen requires a fuel cell (2H2+O2 -> 4H2O + energy) which converts chemical energy to electrical and then to mechanical energy. . Hydrogen could also be stored in gaseous form but it would be hard to pipe such a low density gas. At the current state of technology fuel cells are too expensive, too inefficient, and have too low a lifespan to be commercially competitive [103, pg 1].

These pale in comparison to the difficulties with hydrogen production and building a safe and cost effective infrastructure to distribute it. In a transition state to a sustainable hydrogen economy it will most likely be derived from Hydrocarbons other then oil in particular coal, natural gas, and organic waste/generic biomass. In the long term hydrogen will likely need to be created via water electrolysis. Since all these scenarios even using Coal make for a net energy loss additional power must be built into the grid to generate hydrogen, it's an energy carrier not an energy source. Coal while a now abundant fossil fuel generates a lot of pollution and is not ideal especially when the idea is to get an economy that's independent of fossil fuels. There are really therefore only two options for generating hydrogen via electrolysis, solar power and nuclear power (making use of reprocessing so we don't deplete fissionable materials). The biggest

problem for Nuclear Power in the United States is its public image and therefore the red tape which binds it. Nuclear Power is environmentally very clean except for nuclear waste which is easily gotten rid of by reprocessing and building a giant bunker. Both Chernobyl and Three Mile Island were the result of extreme preventable stupidity (both cases involved running the reactor for a long period of time without the cooling system on reminiscent of nuclear safety inspector Homer Simpson) but they soured a timid public and large-scale nuclear power plant construction likely won't begin until after an oil crunch. Terrorism (ironically funded mainly by oil) adds to these fears. However to start the transition there is a simple way to get some hydrogen off existing nuclear power plants, they can use any off peak electrical hours not required for eminence and put it towards electrolysis. Solar currently has too high a capital cost vs. output (particularly with the new generation of nuclear power plants) and the goal is to make hydrogen energy as transportation fuel. Solar may be viable in the future but nuclear is the way to go for building a hydrogen economy.

The other major difficulty with hydrogen production (once the Auto industry agrees to standardization and starts producing hydrogen cars) is building a whole distribution infrastructure almost from scratch. Without distribution hydrogen has to be locally produced and no matter how bad energy prices get the public won't tolerate small nuclear power plants everywhere, it would be a security nightmare. Natural Gas pipelines are somewhat capable of transporting gaseous hydrogen[114] which will help provide a smoother transition to hydrogen energy. But since the most complicated problem is building a pipeline infrastructure its better to use liquefied hydrogen despite

its difficulties in terms of storage and safety (its very cold must be insulated lest it burn upon contact with oxygen or explode if compressed to any degree).

Despite these difficulties in the long term after an energy crisis they will likely be overcome, despite possible alternatives to hydrogen the oil and automobile industry seem to be tentatively betting on hydrogen to be the fuel of the future in terms of transportation and given that those industries are dominated by a few large companies this will likely be a self fulfilling prophecy. So the fuel of the future is most likely hydrogen.

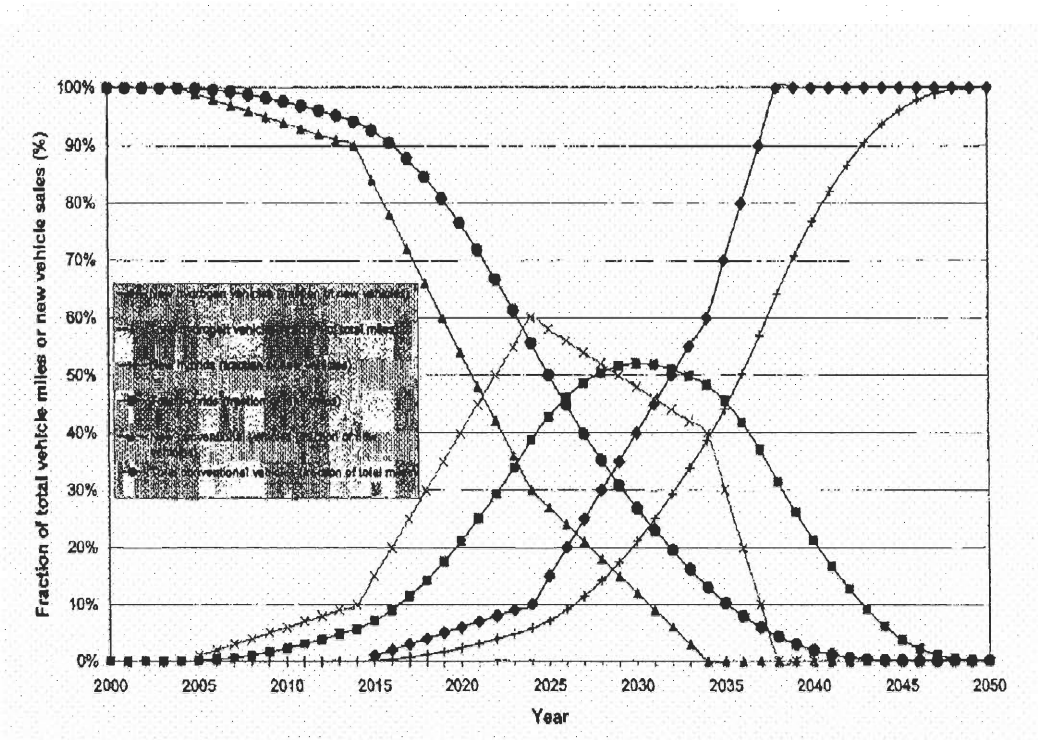

Figure 4-1: National Academy of Engineering's projection of future conventional Hybrid and Hydrogen vehicles [103, page 62]. Since the legend is very unclear an explanation of each line is given below.

+-The cross symbol represents hydrogen vehicles as a fraction of total miles driven.

◆- This diamond represents pure hydrogen vehicles as a fraction of new vehicles sold.

▲- This triangular symbol represents conventional vehicles as a fraction of new cars sold.

✕ -The x symbol represents new hybrids as a fraction of total vehicles sold.

■- This square symbol represents hybrid vehicles as a faction of total miles driven.

The circular symbol represents conventional vehicles as a fraction of total miles driven.

The projections in figure 4-1 predict that the auto industry will shift to hybrids 1st and then eventually to pure hydrogen vehicles once the technology improves.

Policy Recommendations

In the past US Government policy has favored oil mainly by limiting its competition from coal and nuclear power. This writer has no problem with trying to increase our domestic oil production (ala ANWR) but given that oil prices will likely begin to steadily rise to the detriment of the US economy and standard of living in the future the government should try to plan for this eventuality as given the US low level .

While the government should maintain and even increase safety standards for nuclear power plants (in terms of security against terrorist attack and meltdown) the red tape in other areas of the domestic nuclear power sector should be reduced. The Department of Energy should be directed to prioritize approval of construction on new nuclear power plants and expansions on existing ones, regulations and red tape not dealing with safety should be eliminated. Yucca Mountain should be brought online for disposal of nuclear waste and new breeder reactor and Thorium reactor construction should also be streamlined. The government should stress the cleanness of nuclear power to skeptical environmental groups

While this writer is generally not a fan of using taxes to motivate people towards what social engineers deem desired behaviors or away from those they deem undesirable under normal circumstances, the benefits of a smooth rather then sudden and painful transition away from oil seem clear, there should be substantial sales tax breaks for sales on cars which run on alternative fuels and tax breaks for gas stations who carry ethanol etc or hydrogen based fuels and no taxes on their sale to the consumer.

Gas tax increases or oil import tariffs because would be a negative because that would hurt the economy generally perhaps hurting development of alternatives.

Conclusion

If oil price levels do not rise dramatically over their current level, then it is estimated that demand for oil will rise from its current level of about 75 million barrels per day, to between 105 million and 120 million barrels per day by 2020. The projected rise in demand is due primarily to rapid economic growth in East Asia, particularly China.

Future supply projections are more uncertain, but even using the most optimistic projections of future oil supply capacity, world conventional oil production capacity will fall short of skyrocketing demand shortly after 2020, at the very latest. The result of this shortfall in oil production will be a massive rise in the equilibrium price of oil, up to the point where oil consumption falls enough that demand at the new price is brought back in line with supply. This will likely cause severe economic crisis in most of the world (and extremely devastating consequences for those in the developing world dependent upon food imports who are least able to pay) necessitating the development of an alternative energy infrastructure. Given the predisposition of the energy companies, who will collectively determine an alternative fuel from a limited number of options, it seems likely this new energy infrastructure will be based upon hydrogen as a chemical fuel to be used in the transportation sector. The hydrogen in the long term will most likely extracted from water electrolysis or generic organic materials using the cheapest abundant source of non fossil fuel based electrical energy, nuclear power.

The years of transition away from petroleum will be economically painful, and as such the United States should prepare for the coming oil shortfall by streamlining the

building of more nuclear power plants now and pressing the energy and automobile industries to develop standards for hydrogen energy. Industry standards are necessary so that the existing upgraded in a uniform way, so that the automobile industry and the energy industry produce compatible products. The main issues to be addressed will be production of hydrogen, transportation and distribution to what are now called gas stations, and a standardized fuel density and hydrogen state of matter. The infrastructure need a uniform and rigorous set of safety standards.

If no effective preparation is made for the transition to a hydrogen economy in the next few years, while the world oil supply is still sufficient, the coming oil crunch will be more protracted and painful.

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