Oil Depletion - Impacts to Commercial Aviation:

“Houston, Do We Have a Problem?”

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Abstract

A brief discussion is entertained on the impacts of peak oil production on the aviation community and resultant societal risks. Alternatives are considered in context of competing forces. Evidence for assumptions is sourced from current industry journals and from public domain data archived by ASPO.
Australia’s unique situation is briefly discussed with reference to obvious risks.

Introduction

Oil production is currently approximately 86 Million Barrels of Oil per Day (Mbpd). The recent indications of pricing relate to tightness of supply attributed to multiple factors, primarily refinery capacity being reached, and transportation capacity being tight, in the face of increased demand by China and India. Oil supply is commented upon at present as being able to be increased by OPEC production increases, with Saudi production being stated to be able to be increased by 1.75Mbpd at present and up to 5MBPD by 2015, by Saudi government production sources. Note that DOE-IEA AEO assumes year 2030 fuel supply to amount to about120 Mbpd to meet demand.

Unfortunately, recent attempts to increase oil production in Saudi Arabia by Saudi Aramco has appeared to damage production capability at the Ghalwar oil field at least, which accounts for 5Mbpd of a total of 9Mbpd from Saudi Arabia. News reports by Al Jazeera in December 2005 indicated Kuwait's largest field , Burgan, had peaked production and was now in decline, in January 2006, the Dubai Government noted commercial oil depletion within 10 years, and in February 2006 Al Jazeera reported the potential damage of Ghalwar, and possible peak production of Aramco output.

Global unidentified reserves of conventional (light) oil is estimated by a number of geologists using differing techniques as being not more than an additional 10% over that already identified to date. The existing estimates of total conventional oil that can be accessed runs around 2-2.2 trillion bbl from industry geologists, (ASPO) to 3 trillion bbl by Government sources such as the US's DOE-IEA, and USGS (IEA) In respect to accuracy of estimates by any industry source, readers are reminded of the recent history of Shell and the ultimate outcome to it's Chairman and various operating personnel in respect to pending criminal investigations regarding falsely overstating booked reserves. Simmons made the observation in 2005 that one of the greatest impediments to recognizing the extent of the problem remains the industry's failure to have independent audit of reserves.

Unconventional oil supplies are identified as being available from:

- Coal (to Gas) to Liquid (CTL) by Fischer-Tropsch process or similar
- Bitumen-Alberta tar sands
- Heavy oil-Orinoco heavy oil belt of Venezuela
- Biomass
  - Ethanol
  - BioDiesel

Unfortunately, unconventional oil supplies have three significant constraints that continue to be ignored in general literature on the mater of liquid fuels;

- time to production
- production volume
- CO2 emissions

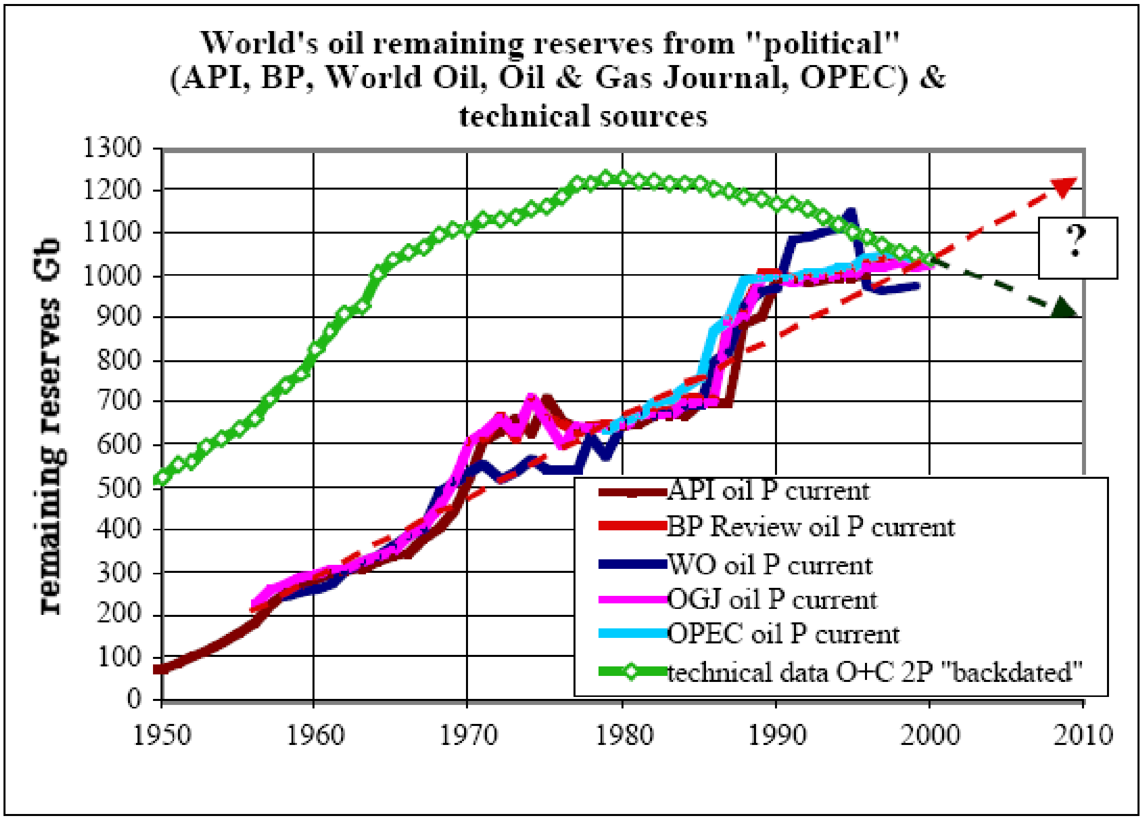

Figure 1. Oil reserves based on reported data (Campbell/Laherre)

Current indications of fuel costs are consistent with the position that peak oil production will occur in the near future, within approximately 18 months subject to global demand, or in fact that they may have peaked in the last 3-4 months but has not become evident due to inventory drawdown (refer TWIP inventory status). The peak is likely to be quite flat for a finite period due to the commencement of some production capacity in FSU states, however also has significant potential to have a significant constriction with existing instability of conditions in Venezuela, Nigeria, Iran and Iraq, with instability in the southern states of FSU having potential to delay or inhibit development of their production and delivery systems.

DOE-EIA annual forecasts (AEO) are available for access and indicate one significant fact; they are based on unlimited or uninhibited oil production capability for the foreseeable future. This scenario is disturbing in light of readily available evidence, notwithstanding the vagueness of official figures related to proven oil reserves quoted by organizations such as BP in their annual reviews.

Troubling is the substantial upgrading of OPEC-ME nations stated proven reserves (a doubling without any surveys or independent audits) that occurred in apparent response to quota guideline tactical positioning in the eighties.

Current fuel costs are running around $73US bbl for WTI, slightly higher for BC or SLC, with Jet A1 running about +$15 above that amount. In early 2006, the first futures contracts above $100 bbl WTI were struck. Swiss Govt reviews of oil prices indicate supply constraints and demand increases raising prices of oil substantially upwards with $380 bbl possible within foreseeable future, note that the US DOE-IEA AEO for 2005 indicates an oil price in 2030 of about $28 bbl.

Demand is a product of population levels and activity, and is therefore affected by the level of affluence of the population. Restriction of energy necessary for basic demands will constrain sustainable population levels, and any sudden restrictions to basic food supplies opens up non linear responses for population changes as a result of the failure of the supply demand models basic premise; the efficient allocation of resources and the potential for structural collapse of the society. In Australia's case, the merit of continued immigration to grow the economy is at odds with the finite immediately available liquid fuels, potable water, and capability of the country to sustain a population. The merit of continued population growth will become questionable in the near term in light of system constraints. Existing population levels are a result of an abundance of a non renewable energy source being used for producing food and powering the structure of society. Restrictions of the energy source are of more than passing interest as a result of the reliance of the population level on it's continued supply.

The abundant supply of coal requires technological development to be expanded as an alternate source of liquid fuels, failure to do so will exacerbate existing stress on climate.

Australia's relatively generous endowments with coal and uranium along with other raw materials may become desirable to other nations. Existing self defense capability is limited to a relatively small volunteer force supported by numerically limited high technology force multipliers. Civil defense reserve capability is deficient to act as a deterrent towards aggressive plays for resources if encountered.

Current global use of uranium is unsustainable in it's present form, yet better practical alternatives exist that have been tested and offer greatly improved balance of risks to rewards in the application of nuclear fuels, positively impacting on intrinsic reactor safety, proliferation reduction, and long term storage of contaminants.

Ultimately, the question of when peak oil production will occur only affects the magnitude of the impending crisis in liquid fuels, it does not alter the inevitability of structural societal change that is necessary. Early intervention (if still possible) increases potential for smooth transitions to sustainable energy supplies and reduced environmental damage. Late intervention, which may well be now the case due to procrastination from late recognition, obfuscation from vested interests, and continued lack of political moral fortitude increases the chances of severe adverse non linear system responses, with potential ranging from global financial disruption through to near extinction. In the face of the existing stark contrasts of outcomes, it is difficult to comprehend that we as sentient creatures are unable to act to protect our own future, that we fundamentally lack the attributes that we Australian's are so ready to remind others about, to do the right thing, and to "look after your mates".

> *"Not a whit, we defy augury. There is a special providence in the fall of a sparrow. If it be now, 'tis not to come; if it be not to come, it will be now; if it be not now, yet it will come - the readiness is all. Since no man, of aught he leaves, knows what is't to leave betimes, let be."*
> - Wm Shakespeare. *Hamlet; Prince of Denmark*

The "Anzac spirit" as it may have once existed, is certainly not in evidence in actions by this society at this time.

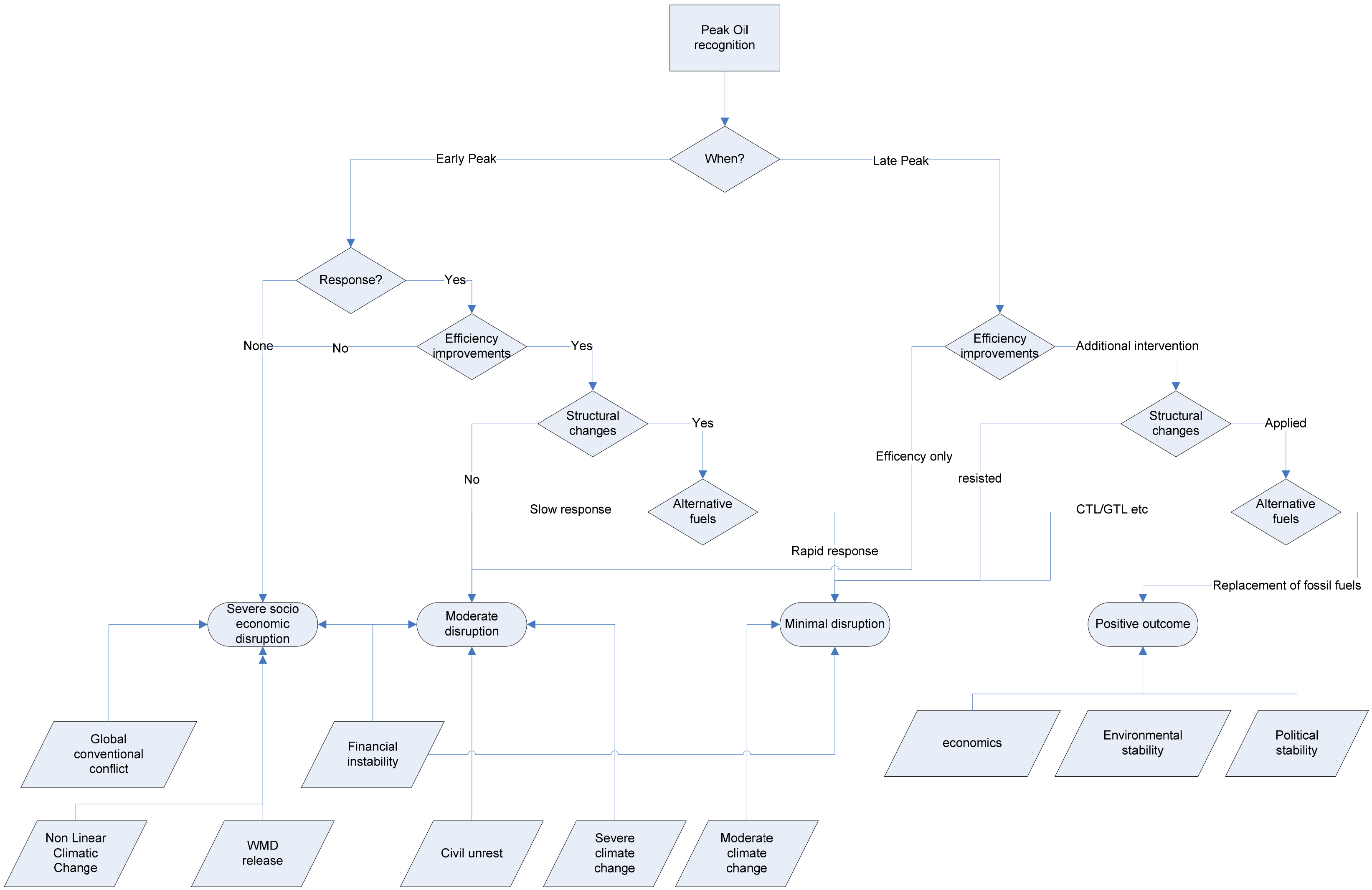

Chart 1. Alternative course of action

Discussion

Is the cost of fuel today a result of “Peak Oil”?

Not really, yet… the current crude oil costs are a result of some levels of uncertainty on geopolitical issues that affect the normal supply chain which results in an uncertainty premium being applied to the base price of the commodity. Current inventory levels of crude are near historical norms so constraint in supply ha not yet occurred. Refined product inventory has been affected by seasonal demand and also by change over in winter to summer blends in the US for gasoline products, and is near limit conditions for refining capacity. Base oil supply has been affected by a restriction of approximately 2.1Mbpd from the combined effects of the US hurricanes, and reductions in Iraq and Nigeria, but as yet does not constitute a constraint on supply such as to directly affect oil costs. What we see is the affect of fear, not the actual root cause.

Post peak oil supply, the price of oil will be driven by supply/demand, uncertainty, and the fear associated with the diminishing supply availability vs the demand curve overshoot due to systemic lags. Lag exists in demand destruction and in shift from conventional oil to alternatives such as unconventional oil and sustainable replacements.

The cost of fuel during the recognition period of peak production may result is substantial and almost irrational pricing behavior, in the absence of management to alternatives.

In context, current fuel costs remain historically low, and are veritable bargains against commodities such as Coca Cola, Evian, etc. The difference is the structure of our society has been developed with the assumption of readily available liquid fuels, and they pervade all aspects of commerce and life in general, having become vital to societies functioning.

Does Commercial Aviation really matter?

If oil becomes significantly more expensive than today (which still is about the same as the early 80’s corrected or inflation, we got used to cheap energy…), economists would likely argue a series of market corrections would occur:

- “other” oil would appear, that oil which the new balance of costs and revenue would make attractive to produce, i.e. non conventional oil

- Economy of operation would occur, other costs and efficiencies would be entertained
- Substitution of product would occur. People would take trains and ships rather than planes, FedEx uses trains

Unfortunately, the world has become accustomed to travel, and the existing global economy indicates the largest industry is Tourism, the industry most affected by oil depletion. It would appear that aviation's potential demise due to increased costs would have some significant knock on effects given that it underpins the largest single part of the global economy. Within the US alone, direct attribution to Aerospace support is approximately 10% of GDP, not including tourism.

Per barrel of crude oil, jet fuel averages 9% of volume produced, a barrel being 42 USG being processed on average into 45USG of product. Jet fuel is a specialized product.

ASPO archives contain a disturbing document related to system energy availability vs population growth, which raises the spectre of some immediate constraints to non conventional oil substitution, "The road to Olduvai Gorge". It has a central premise that oil has underpinned the population growth in food supply, increasing productivity both directly and indirectly, and becomes a significant constraint to reallocation of biomass towards liquid fuel production to offset oil production depletion (note that lots of conventional oil remains, unquestionably, but the production rate is unsustainable beyond rates that are consistent with existing levels).

Product	Gallons Per Barrel
Gasoline	19.4
Diesel & Home Heating Oil	9.7
Kerosene-type Jet Fuel	4.3
Coke	2.0
Residual Fuel Oil	1.9
Liquefied Refinery Gases	1.9
Still Gas	1.8
Asphalt and Road Oil	1.4
Petrochemical Feedstock	1.1
Lubricants	0.5
Kerosene	0.2
Other	0.4

A 42-gallon barrel of crude oil yields 44.6 gallons of product "processing gain."

Table 1. Average yields for U.S. refineries in 2000. Available online at: www.eere.energy.gov/industry/petroleum_refining/profile.html.

Figure 2. Average US yields from oil

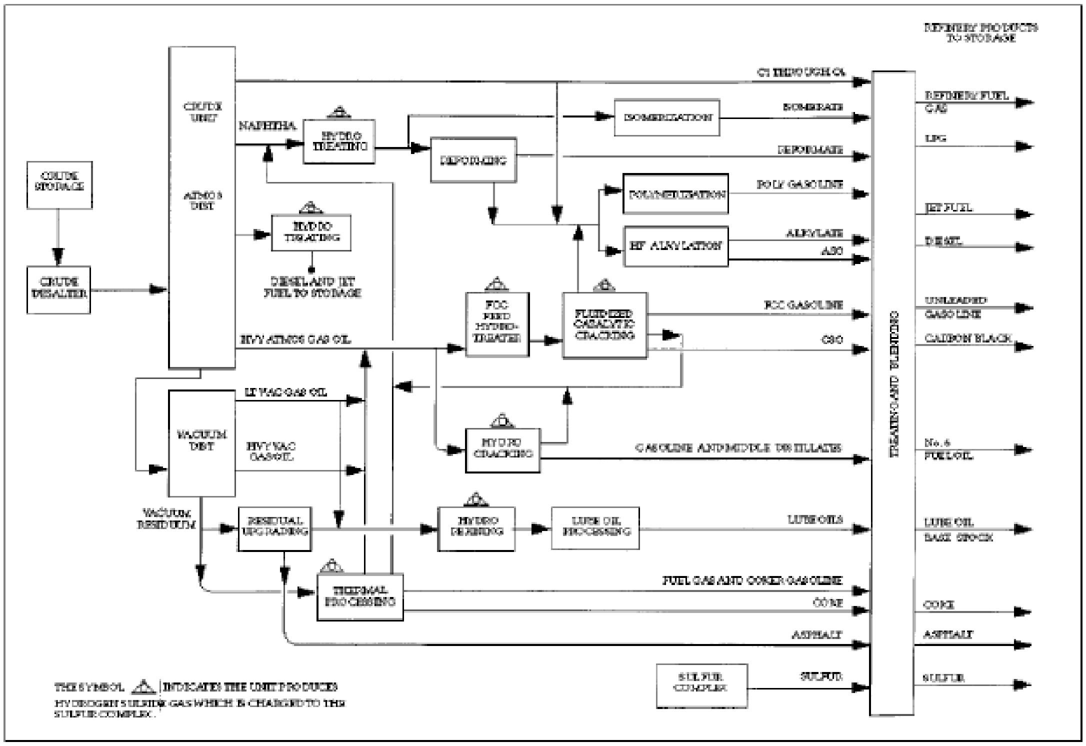

Figure 2. Simplified refinery process flow diagram.. From the Petroleum Refining Industry Study, www.eere.energy.gov/industry/petroleum_refining/pdfs/profile.pdf.

Figure 3. Refining Process

This premise raises concerns on the rate of decay of oil production in the existing system structure, and a quick assessment of potential decay rates indicates that critical non linear system responses such as anarchic public behavior, global energy grabs etc, are achievable within historical recorded post peak oil production decay rates, which would make the central issue of energy constraints somewhat cerebrally concentrating.

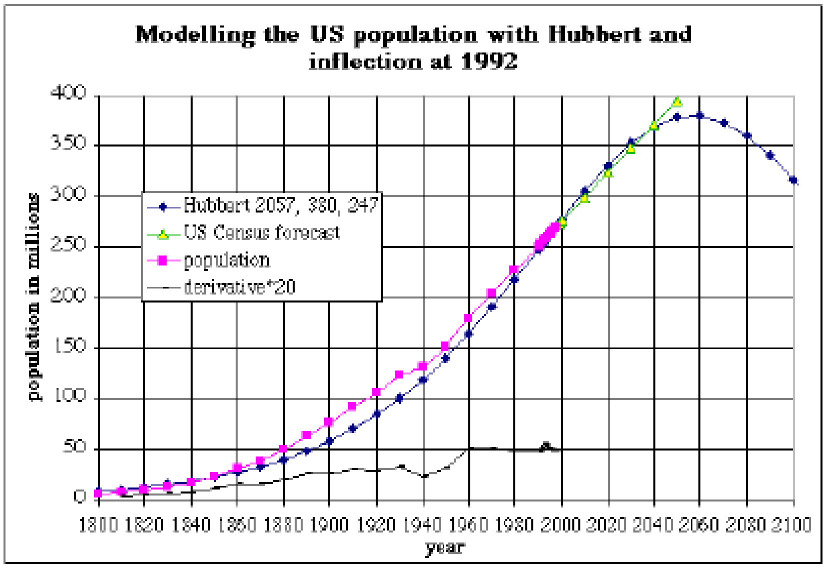

Figure 4. Population correlation to oil supply USA (Laherre)

Are alternatives really alternatives?

Alternative actions are possible but all require ramp up time to implement to avoid excessive political and economic disruption (mayhem) post peak:

- CTL(GTL); cost effective above $30-$35bbl. Benefits are bountiful supply of coal, but not necessarily strategically placed. Most significant constraint is CO2 emission which requires sequestration and not just carbon credit to facilitate. Note that potential non linear system response to Global Warming has potential to result in near extinction within the foreseeable future should the food chain be constrained to the extent that a severe overshoot of global carrying capacity is exceeded (say 6.3B to 350M population, experimental observation has resulted in an equivalent outcome as low as 5.5M without positive intervention). Production delay appears about 4 years in a crash program without bypassing normal EPA regulatory approvals/Kyoto Protocols. Bypassing, supply in 3 years. Costs run approximately $20,000USD per BOE per day, and is modular in process. Benefits are
  - o direct final product processing, designer fuels,
  - o ready collection of CO2 during manufacture process
  - o proven technology, (SASOL, Germany)
  - o Production volume constrained by investment (current ROI is 100% in less than a year)
  - o Politically stable supplies
  - o Recent research (SASOL synthetic JET-A1, Gilberton, PA/USAF JP-900)

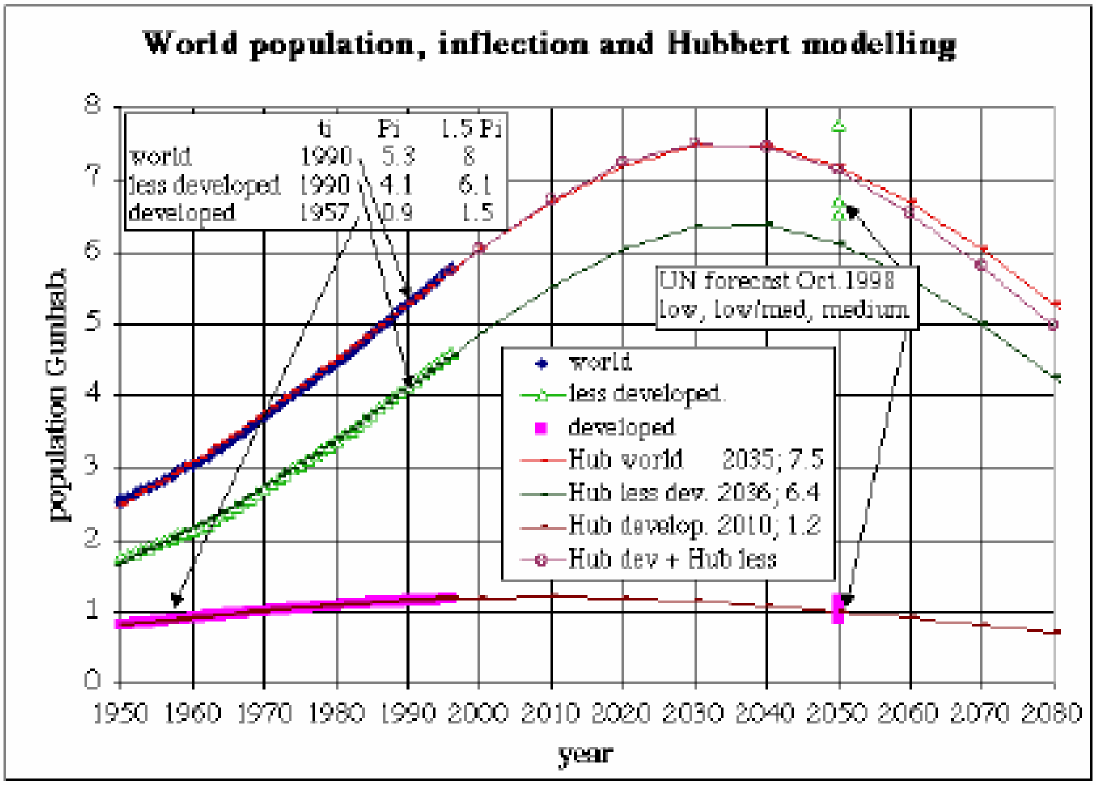

Figure 5. The Hits just keep commin' (Laherre)

- Alberta Oil/Tar Sands: expensive extraction, environmental disaster in current process with CO2 emission and water usage. Limited production capacity constrained by water availability and electrical demand is currently ignored. Production is not likely to exceed ~3Mbpd by 2020, even with increases in water and electrical supply which will not make a significant change to post peak declines. Benefits are difficult to justify in the context of the impediments to production.
- Orinoco heavy oil. Venezuela's heavy oil deposits are potentially extended down the East side of the Andes for the whole length of South America but have not been well established beyond the Orinoco belt. Production costs are high but are now within economic viability in the current and foreseeable future. Yield in total energy cycle terms is not high, but in a world of constrained liquid hydrocarbon fuels it is acceptable in the short term.
- Biomass. Any significant diversion of food supply to fuel production raises concerns with population management, and system instability, the "Olduvai Gorge" scenario, particularly with crop diversion such as corn and similar.
    - The technical constraints are minimal but do exist:
        - Ethanol: relatively low energy densities, corrosion
        - BioDiesel: low energy density for jet use, (freeze point?)
        - Energy demand for production

- o Benefits include:
  - Closed CO_2 system (IF production energy derived by similar fuel supply)
  - Minimal but possible CO_2 sink
  - Renewable supply
  - Potential coupling of future population growth to a sustainable liquid energy supply
- Hydrogen. Not an energy source, a transport medium. H_2 requires production by other source such as H-C cracking, H-O electrolysis, which requires either heat and catalysts, or electricity. H_2 has low energy density, storage, and handling problems. Safety is, and will remain, a significant issue with H_2 fuels in any form other than in place cracking systems such as fuel cells.

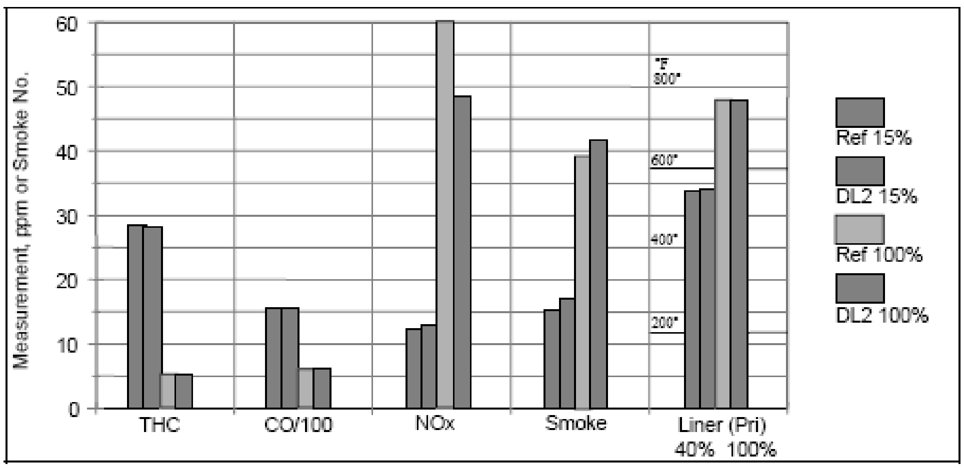

Figure 4. Jet Fuel and Reference Fuel Properties

Figure 6. SASOL test values synthetic JET-A1 from GTL (SASOL)

Time Line Constraints

Time is definitely NOT on our side, solutions for continuance need to be already developed to avoid disruption, and that is not the current case.

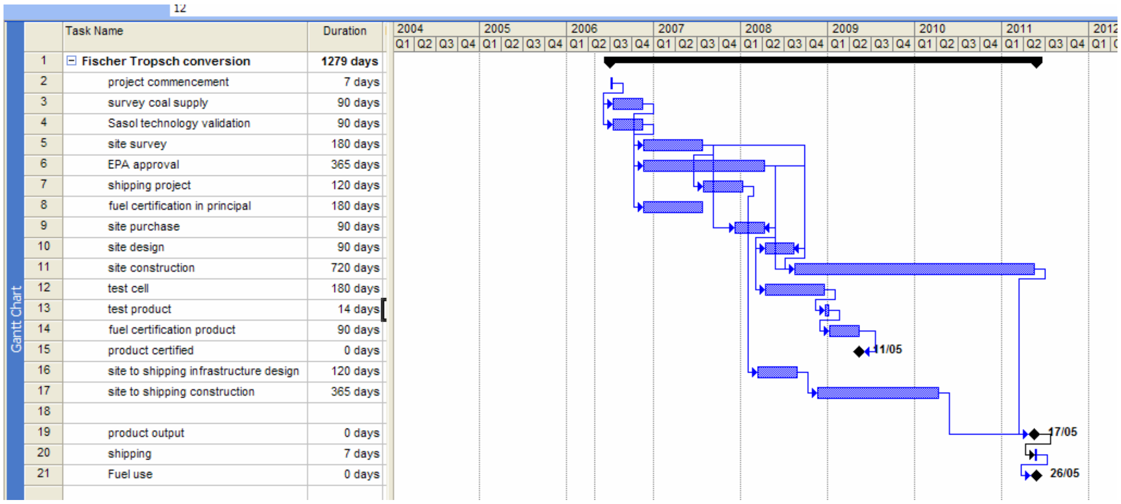

Figure 7. F-T Project; Normal Risk Based Project Structure estimate

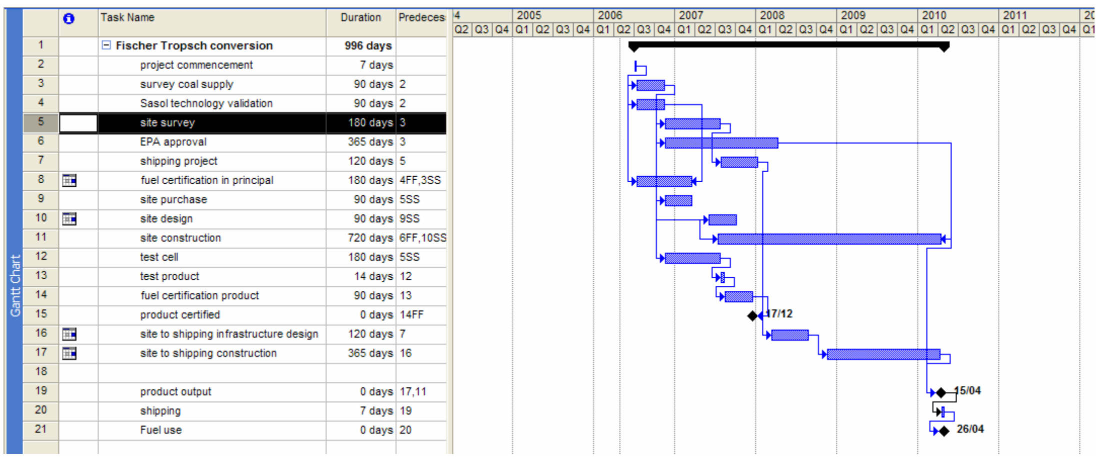

Figure 8. F-T Project; CRASH program estimate

While F-T CTL Jet A1 is potentially viable within a reasonable timeframe, validation of process is necessary as the original SASOL development was derived from natural gas reformation, GTL, not CTL from coal stock (SASOL process [blend] attempted approval to British SAE Standards in 2005). Existing LNG proven reserves are going to peak approximately 20-25 years post peak oil (total) production, and, due to the unique characteristics of gas production will occur with a rapid decline with little forewarning. LNG therefore is a poor long term prospect for CTL production in other than exceptional circumstances (refer Qatar/Omani LNG developments).

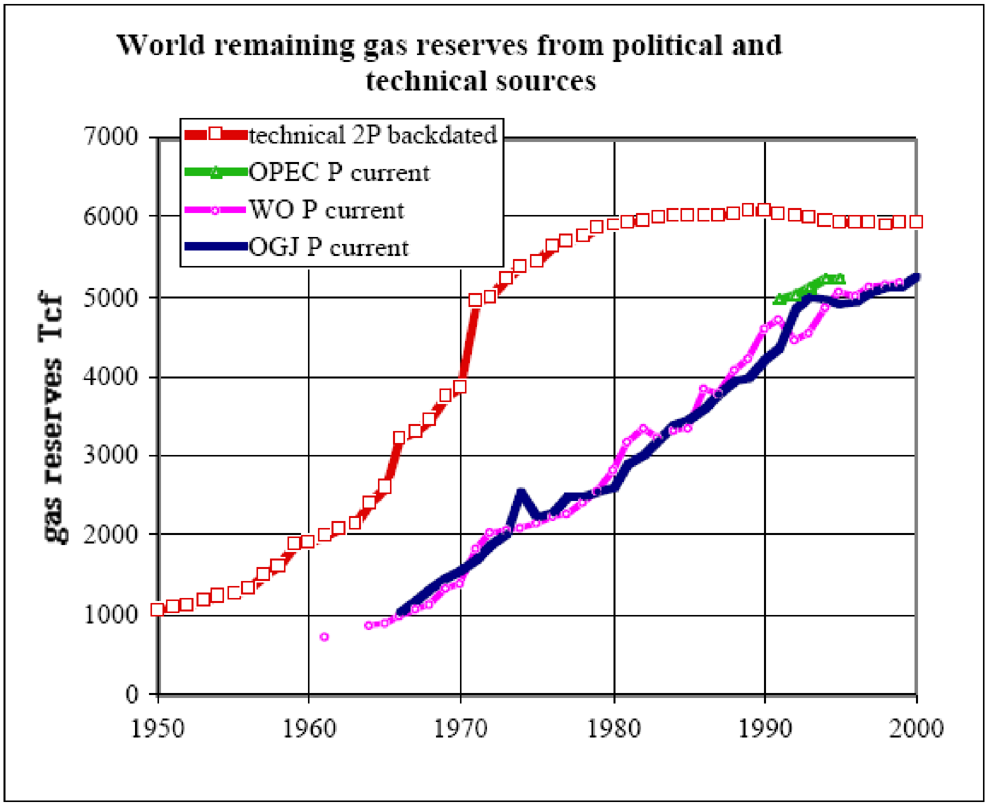

Figure 9. Gas is not a long term solution

The time constraints for the aviation community will be compromised by rapidly escalating conventional fuel costs and reduced economic capacity to invest in fuel supplies without government intervention.

It is hard for this observer to see development of alternative fuel supplies in an acceptable time frame as a result of basic Supply-Demand economic balances as envisioned by Adams or as expanded upon by Porter's competitive economics models. Recall that in the great oil squeeze of '73 by OPEC that the supply short fall was in the order of 4% reduction from existing demand equilibrium, and resulted in a 400% increase in cost.

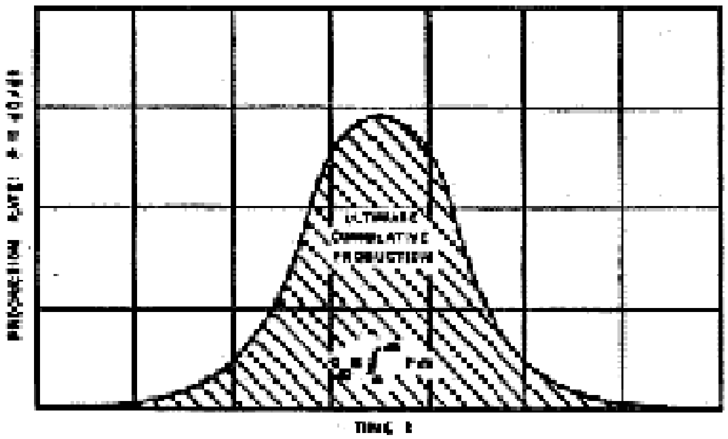

FIGURE 8 — Mathematical relations involved in the complete cycle of production of any exhaustible resource (Hubbert, 1956, Fig. 11).

Figure 10 W. King Hubbert's original analysis of Lower 48 Oil depletion

Production decay rates are not necessarily going to be consistent with W. King Hubbert's curve of 1959 which was specifically derived for the lower 48 US state production, but can be expected to grow towards 4-8% minimum decay rates within approximately 5-10% of time from start of production to peak occurrence (Global peak will be more gradual due to staged peaking but there is a significant percentage of total current production that was commenced before 1970, and will be reaching maturity of production at similar times, affected by intervening political events during the production cycle).

So where are "We" today?

Looking out the window, there are rather few cryogenic H2 trucks running up to our shiny new B744's and A330's. Radiation signs are not in evidence on the engine nacelles of the B737-800/900 or the B777 so one would assume that the current state of play is a continuation of our existing operational dependency on liquid hydrocarbon, and thus probable economic threats from peak oil production and resultant catastrophic demand led fuel costs and limited availability (the military has a substantial existing demand and a reasonably predictable increased requirement for fuel as a result of national interests related to energy reliability, a consequence of the USA's '70's conscious decision to accept dependency over efficiency, exacerbated by the oil glut of the '90's).

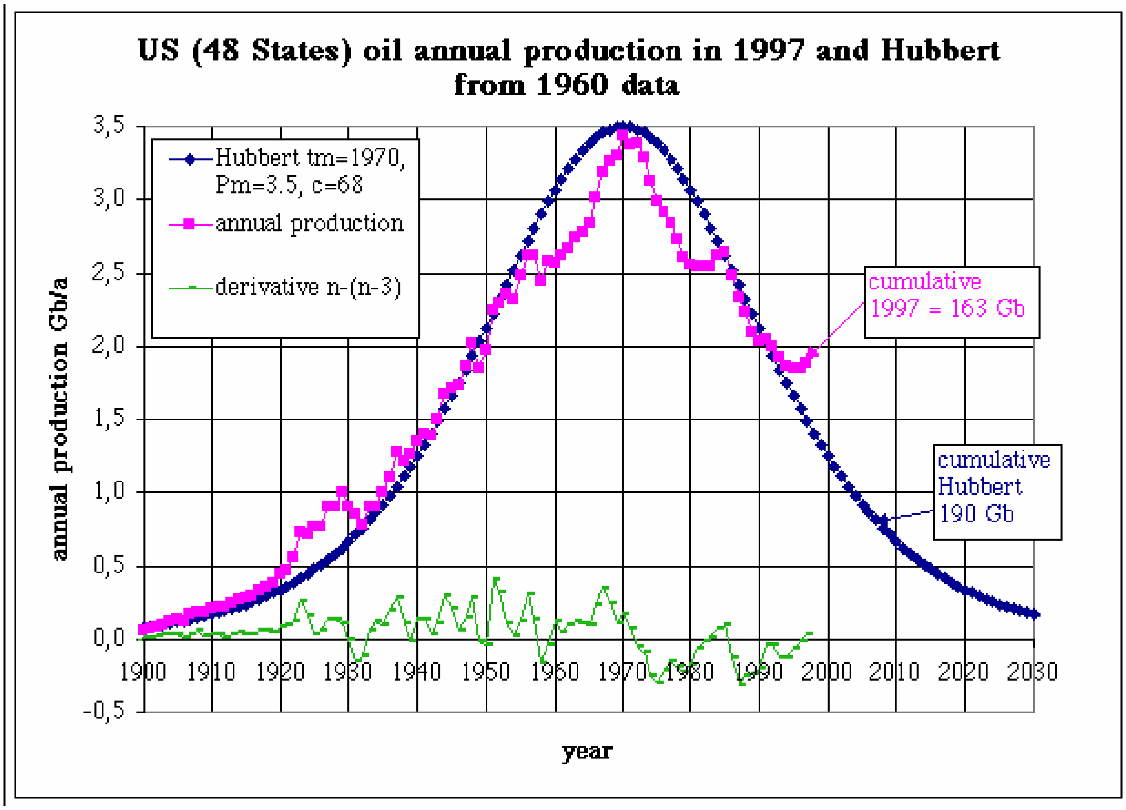

Figure 11. Hubbert's curve from beyond the grave

It would appear that for better or worse we are restricted in our immediate responses to fuel supply shortages:

- Aircraft efficiency gains; not short term solutions in the main. Historical gains have come from engine and aerodynamic improvements, and are mainly evolutionary incremental improvements, rather than revolutionary order of magnitude changes (the B787 resembles a B757 with better range, more than it does a new breed of bird).
- Operational efficiencies have in the main been implemented where possible and the main residual improvement is in the areas of:
  - Point to point navigation,
  - Optimum altitude operation through reduced lateral/longitudinal and vertical spacing (free flight)
  - Optimum Max Range Cruise
  - Minimum ground running; tow in/tow out (tow vehicle GPU?) to start point/from stop point.
  - Optimum climb/descent profiles (minimum drag)
  - Removal of noise abatement constraints
  - Removal of speed restraints beyond optimum configuration
  - VFR type terminal maneuvering
- Load consolidation
- Extended carrier load sharing
- Customer education to increased costs; (a substantial double edged sword, the risk of peak oil on global economics is not the physical

occasion of peak oil production, it is the point of public understanding and any loss of confidence in the existing financial institutions if it is mishandled). Note that costs in inflation adjusted terms are far lower than in preceding decades, but the growth of low cost mass travel and hence the potential adverse impact to global financial health has been a result of increased prosperity increasing demand, and lower costs of supply.

- Commence investigation into cutting jet fuel with bio diesel or ethanol. Testing has been conducted in Brazil on Ethanol use in turbine engines (Embraer), and limited testing has been done on in flight combustion and performance effects of Ethanol by UT.
- Commence investigation into development of F-T based CTL (or GTL if necessary) synthetic Jet-A/Jet-A1/JP-900, being mindful of the time constraints and investment demands. CO2 sequestration needs to be assured to avoid severe environmental impact.

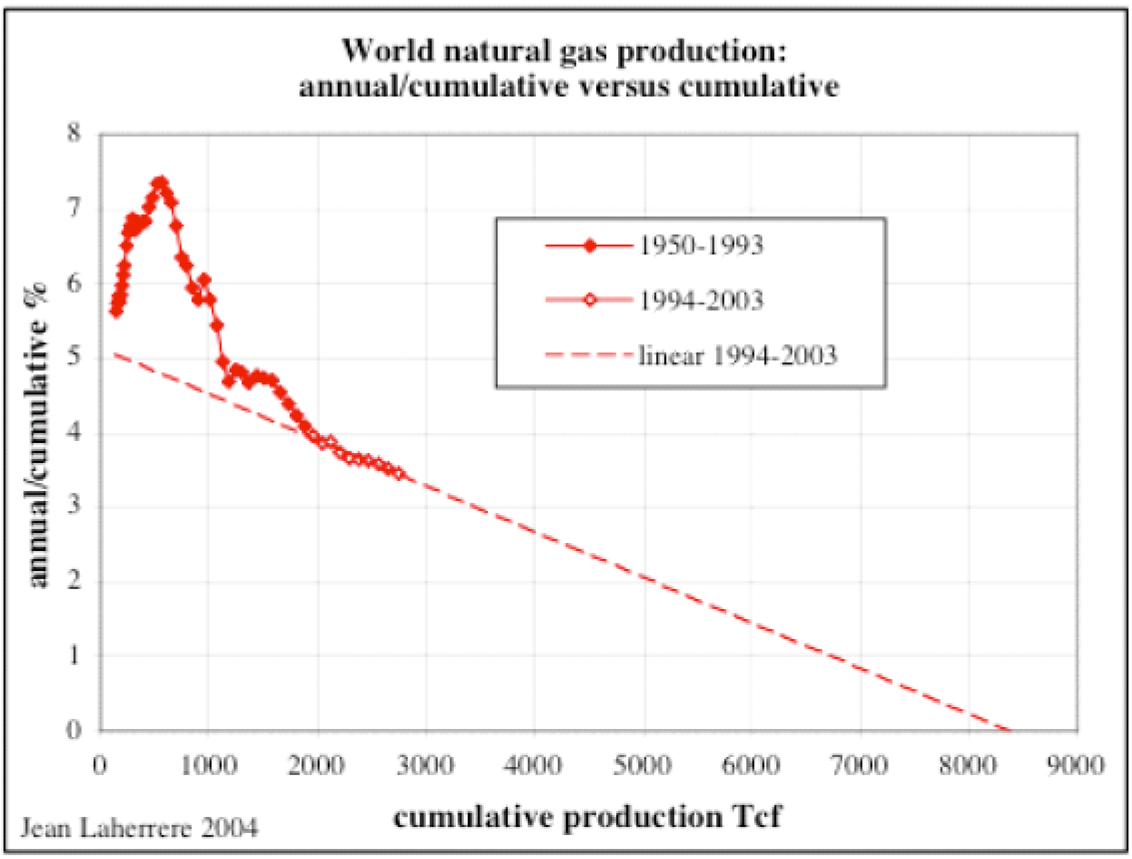

Figure 12 Gas Production; not the answer (Laherre)

Global Energy State

Near term criticality occurs from liquid hydrocarbon production constraints rather than total energy constraints, however gas supplies are going to peak in the near term also. Current electrical supply is generally dependent on coal and gas, with a low level of nuclear (other than France) and hydroelectric generating capacity.

Non conventional generation is possible with renewable supplies but the total end to end energy costs need to be considered to assess merit. The payback for PV, wind, and similar generation is long term and adds to potential liquid fuel deficits in the short term.

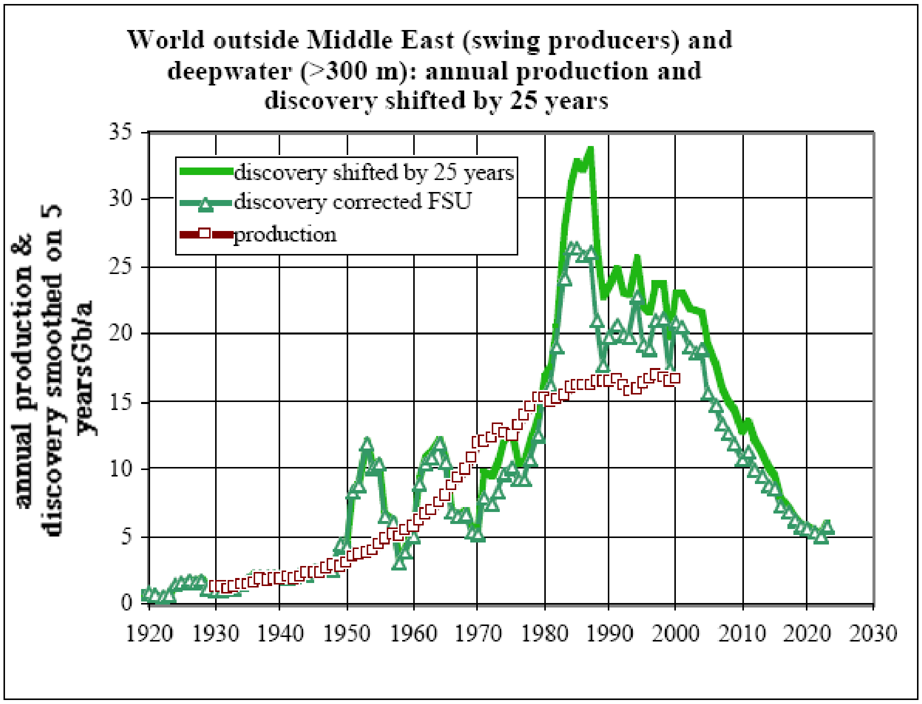

Figure 13. Discovery shifted 30 years vs Production (ASPO)

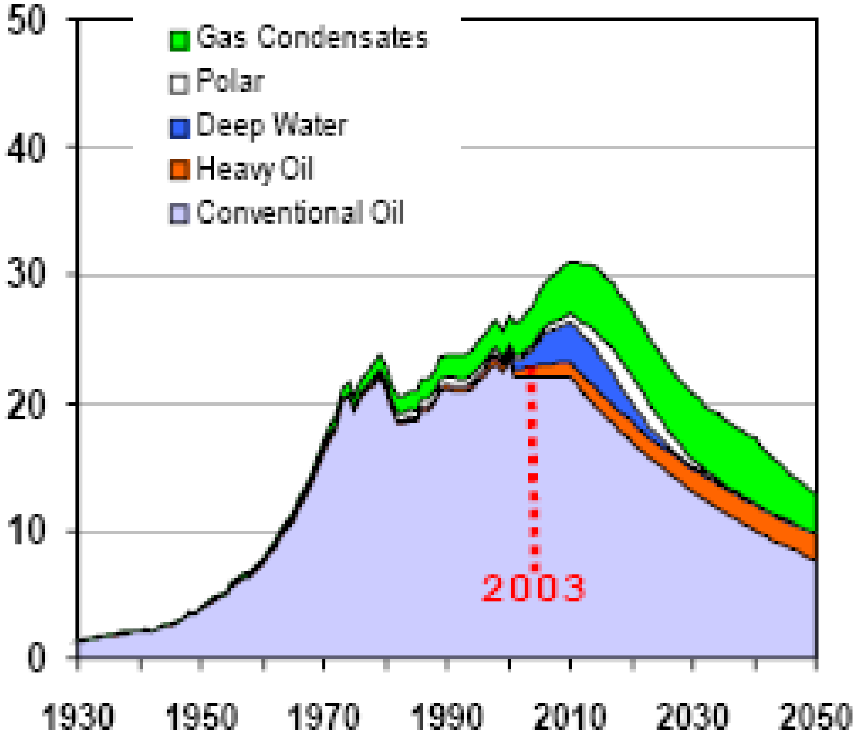

Figure 14. Global Liquid Fuel production (ASPO)

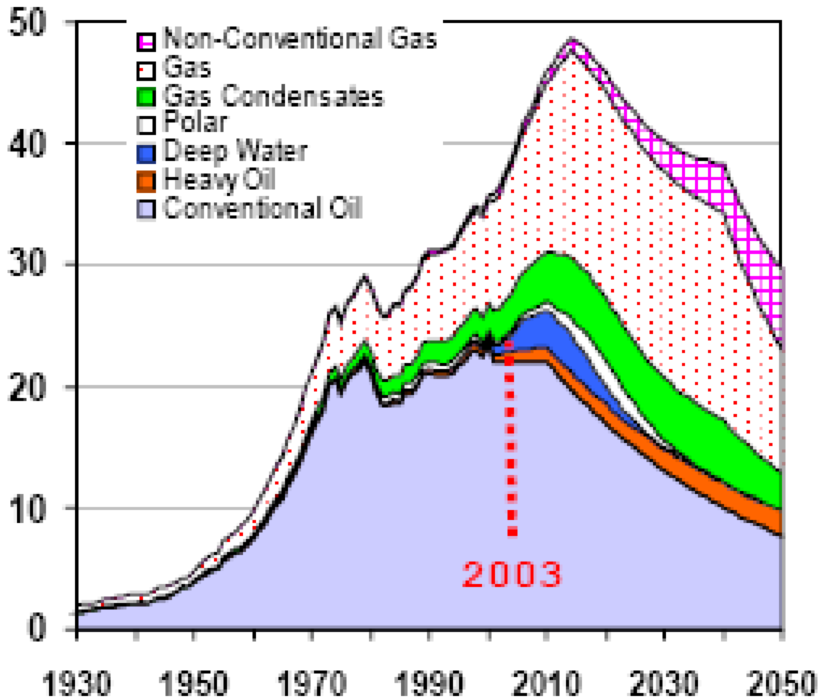

Figure 15. Global liquid fuel production including gas (ASPO)

Bottom line? We have not found sufficient reserves since the ‘70’s to assure continued supply of liquid hydrocarbons beyond the end of this decade.

Nuclear electrical generation. Proliferation or Panacea?

Existing nuclear power generation is based on liquid cooling; water or occasional sodium cooling of the core and for energy transfer to heat exchangers for electrical production. Co-generation is not conducted and efficiency suffers as a consequence. Raw feed proven Uranium reserves are in rather short supply, raising the requirement for reprocessing and increasing the proliferation risks. The fuel fraction consumed in generation results in substantial storage demands that are not well addressed today. A change to gas cooled reactors (GCR) opens up interesting possibilities whilst avoiding many of the greatest concerns of nuclear power generation. Pebble Bed Modular Reactors (PBMR, MPBR or in Germany, AVR) are inherently stable in fission, with no risk from a coolant gas leak to the reaction stability, or likely radio nucleide release. Proliferation becomes difficult as the fuel is locked within the ceramic structure, requiring separation to produce a raw material for processing which may or may not be possible. Fuel grade can include U, PU, and TH which increases fuel availability by orders of magnitude, allowing potential development of land transport by H2 derived from electrolysis or by using residual thermal energy to do CTL reformation of liquid hydrocarbons (subject to CO2 sequestration requirements). Recycling of the fuel and the stability of the fuel coupled with the embedded structure of the nuclear material within it’s own ceramic matrix potentially simplifies the long term storage of waste, as does the omission of liquid contaminant waste, soluble or free particulate radio isotopes from the generation cycle. Manufacture cycle still entails potential proliferation and contamination risks, but equally can reduce global risk at the same time by burning PU and other existing isotopes.

“Time, gentlemen…”

Oil production WILL peak at some time, unless the Russian assessment of anerobic oil production really does mean oil has no end. Of current known reserves (misstated, misrepresented, or otherwise) normal recovery is limited to 30-35% of reserves through the physics of extraction process. Enhanced oil recovery methods such as steam injection, horizontal drilling increases recovery to approximately 50-55%, but while a recent post ‘70’s development, has been factored into recent oil finds when determining reserve capabilities. Oil extraction is subject to the normal economics of profit and loss in respect to recovery energy, and the oil fields become Nett energy sinks well before they become fully exhausted. There is little merit in expending 100bbl’s oil to recover 50bbl oil, and that point occurs in the last 1/3rd of the field depletion. Ultimately, peak oil may well occur near 50% of total reserve extraction, but is much closer to the end of the supply of oil than one would at first assume. Colin Campbell, as a prior educator of petroleum geologists for Shell and other companies along with being a lead geologist, Jean Laherre, principal statistician of Total, Jeremy Leggitt, chief science officer for oil companies and principal science officer for Greenpeace UK are reasonably in agreement with their assessments of oil availability, based on geological basis rather than political or commercial expedients. Simmons indicates serious questions on the reliability of OPEC-ME self assessment of reserves that may salve some consciences, however what is difficult to deny is that current demand for drilling rig operation is the greatest that has ever been for oil or gas, yet there is no commensurate expansion of existing reserves or production from any of th major established fields that we currently rely on for the current demand level, let alone the expected annual increases from China and India. China's current internal energy program has the hallmarks of a "crash" program, and their current diplomatic overtures to Nigeria and other producer nations raises the question as to what is their concern based on. Industry investment in both refining and transport infrastructure is grossly deficient for the assumed 140Mbpd case as forecast by DOE-IEA AEO and again raises the question as to why, even with tight refining capacity (and acknowledging the difficulties of EPA approval for such works, in association with the growing NIMBY resistance are real constraints) that no expansion program for refining or transportation is evident?

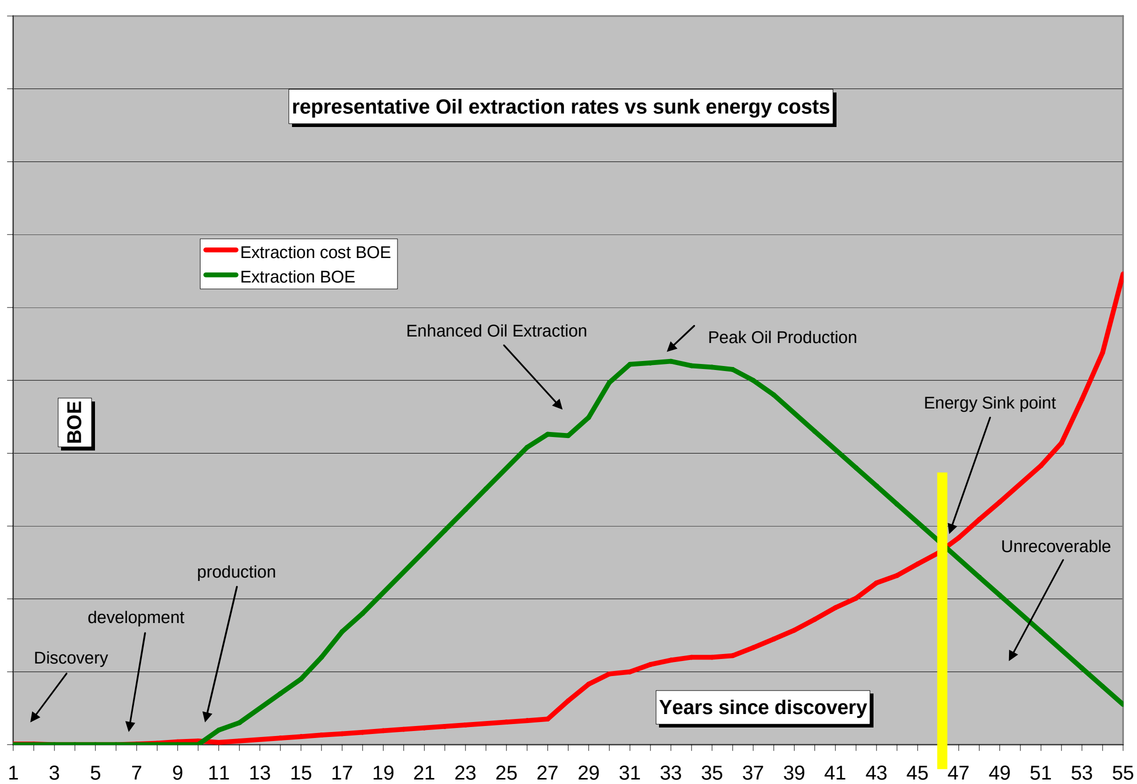

Figure 16. General representation of oil extraction

Risks

The potential for global financial and political turmoil following mishandled peak oil is difficult to convey with sufficient emphasis; historically similar events have tended to result in complete loss of the civilization for a substantial part of human history, as in the case of the advanced Egyptian Phaeronic period. It may be considered alarmist to state that civilization has infrequently been faced with the level of risk that now exists from the impacts of mismanaged peak oil, however there is little evidence of workable economic models that allow for demand destruction or market capital reduction in an orderly manner. Should such a process exist then the problem would be less critical in it's outcome, however the nearest possibilities to such a capability that exist in centralized economic management has been shown to generally fail in practice, and is unlikely to be politically acceptable in the current global climate.

Risk Severity Matrix

5	**Conventional terrorism**				
4				**Peak Oil**	
3		**Biological/ nuclear terrorism**			
2			**H5N1 Bird Flu**		
1					**Global thermo-nuclear war**
	1	2	3	4	5

Impact

Figure 17. Risk Severity Matrix; Likelihood vs Impact

The primary risks result from compounding of reduced food yields with loss of confidence in the existing institutions, and subsequent loss of societal order. Technologically society has a finite capacity to improve efficiency over a given period of time, and supply restrictions beyond that point results in demand destruction where that may be possible. Obviously with food that is more than of passing interest to the consumer. A further boundary exists with voluntary/discretionary reduction of demand where that is possible, which increases efficiency. With liquid fuels, discretionary use is a substantial component of total consumption and gains can be achieved in that area, however, the reduction in activity will impact global economy severely, as the industry most affected by the discretionary use of fuel is also the largest part of the economy.

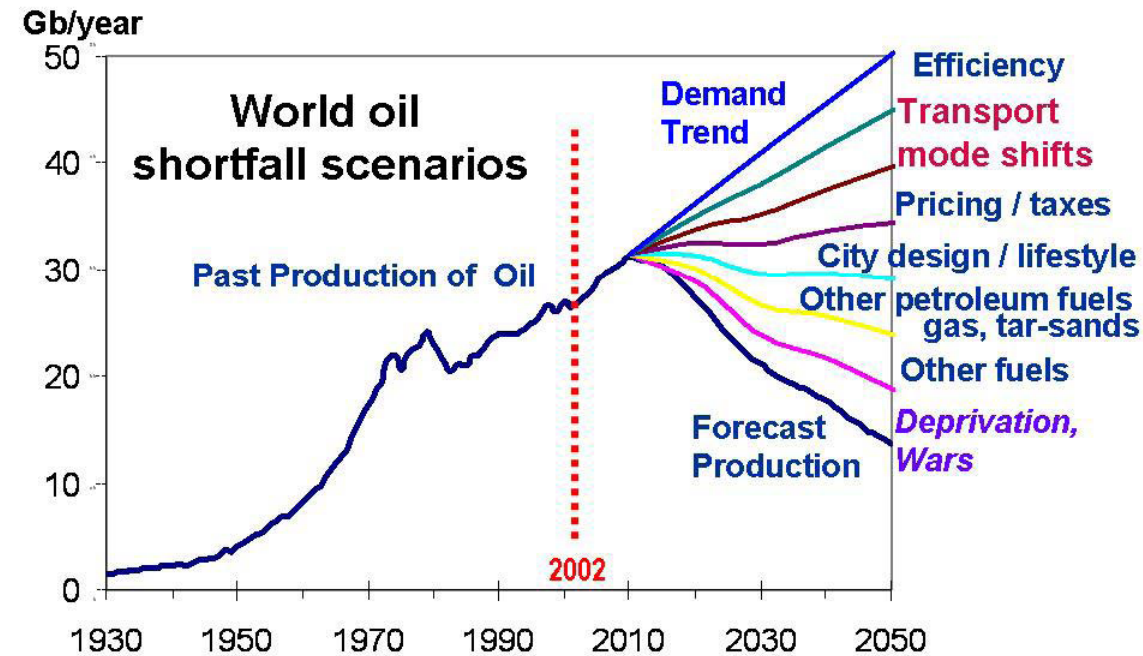

Figure 18. Outcomes (Swenson adaptation)

It would appear that managing the change over from a plentiful supply of cheap oil to constrained supply of more expensive oil is worth the effort, given the potential for improved economics in the current situation vs existing cost bases, and the significant downside of failure to respond to the issue.

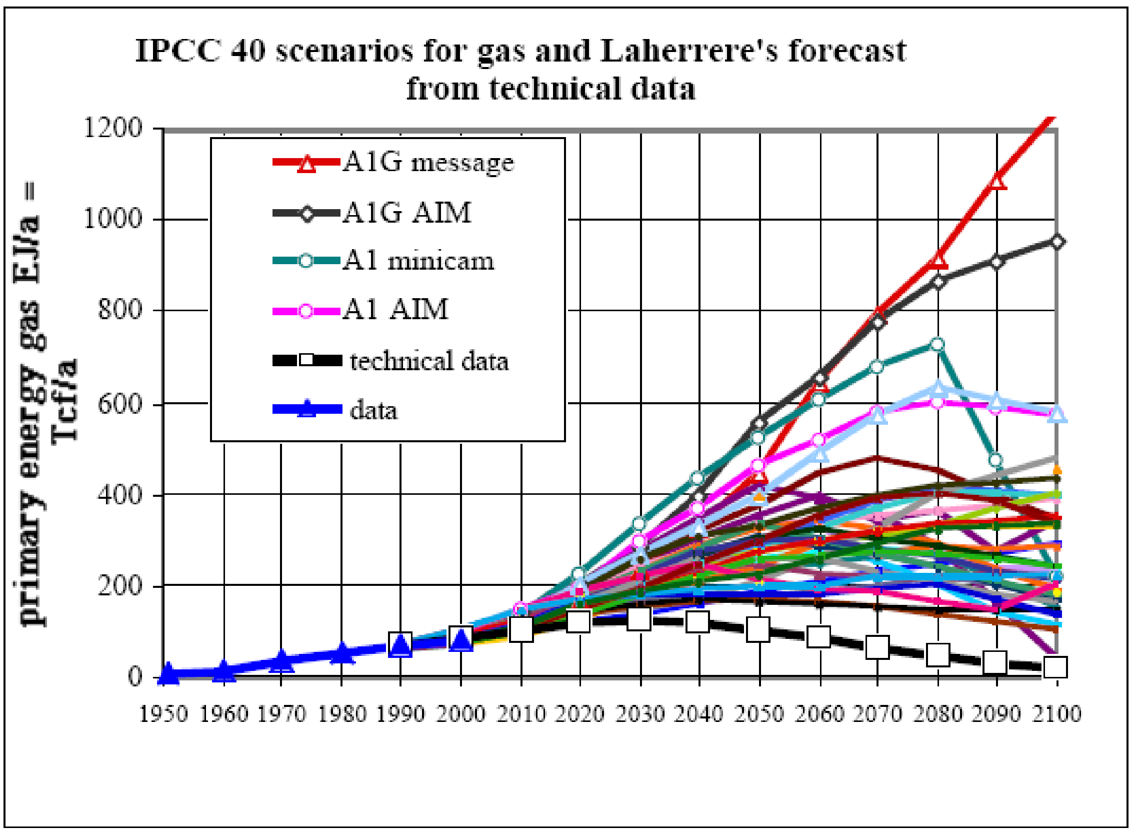

Figure 19. Laherre's data vs IPCC data.

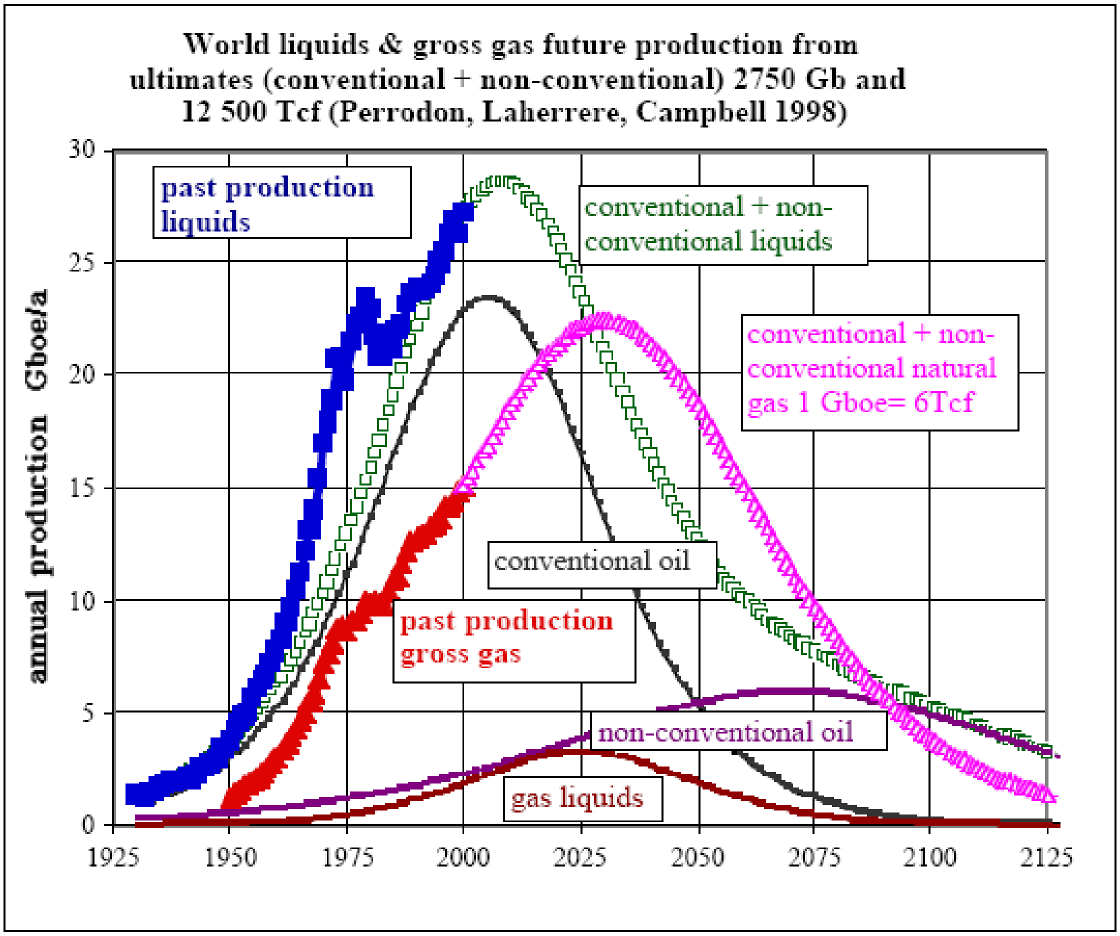

Figure 20. Estimates of Liquid Production

AVERAGE CRUDE OIL IMPORT COSTS (USD/barrel)

	France	Germany	Italy	Spain	UK	Japan	Canada	USA
1985	..	27.93	27.38	27.15	27.63	27.90	27.85	26.78
1986	..	14.88	13.83	13.87	14.07	16.08	16.00	14.71
1987	..	18.32	17.78	18.29	18.05	17.99	18.59	17.73
1988	..	15.26	14.86	14.42	14.92	15.47	15.48	14.33
1989	..	18.23	17.48	17.22	17.60	16.91	18.56	17.50
1990	..	23.17	23.23	21.88	22.92	22.64	24.15	21.07
1991	..	20.36	19.14	18.50	20.06	20.14	20.83	18.23
1992	18.94	19.13	18.30	17.31	19.07	19.30	19.46	17.73
1993	16.05	16.88	15.87	15.13	16.58	17.47	17.19	15.87
1994	15.76	15.81	15.49	15.24	15.83	16.48	16.30	15.06
1995	17.14	17.07	16.90	16.96	17.29	18.02	17.76	16.74
1996	20.82	20.68	20.53	20.45	21.08	20.55	21.26	20.16
1997	18.99	19.01	18.88	18.34	19.32	20.55	20.59	18.34
1998	12.43	12.48	12.21	11.80	12.64	13.68	13.15	12.02
1999	17.45	17.51	17.10	16.99	18.01	17.38	17.85	17.06
2000	28.18	28.09	27.77	27.16	28.45	28.72	29.10	27.54
2001	24.13	24.15	23.87	23.32	24.45	25.01	24.87	22.07
2002	24.63	24.40	24.34	23.95	24.58	24.96	24.97	23.52
2003	28.87	28.44	28.58	28.13	29.13	29.26	29.53	27.66
2004	37.61	36.65	36.60	36.03	37.75	36.59	38.13	35.86
3Q2002	26.48	26.43	26.07	25.92	26.98	26.47	26.70	25.65
4Q2002	26.58	26.46	26.28	25.74	26.68	27.32	27.31	25.28
1Q2003	31.79	31.29	31.35	30.84	32.35	30.97	32.73	30.54
2Q2003	25.90	25.30	25.86	25.38	26.13	27.86	26.56	25.75
3Q2003	28.11	27.92	27.86	27.72	28.45	28.55	28.95	27.35
4Q2003	29.54	29.10	29.06	28.78	29.53	29.47	29.52	27.45
1Q2004	31.86	31.11	31.02	30.70	31.87	31.69	32.72	31.05
2Q2004	34.54	34.10	34.06	33.82	35.00	35.37	35.08	33.80
3Q2004	40.85	39.71	39.22	38.58	40.77	38.95	39.84	38.01
4Q2004	43.05	41.49	42.03	40.88	42.71	40.44	44.96	40.30
1Q2005	45.45	44.56	43.83	42.40	46.20	41.68	44.02	40.50
2Q2005	49.44	49.13	48.56	47.41	49.76	50.56	49.84	45.87
3Q2005	59.50	59.45	57.31	57.17	60.94	57.23	58.47	55.96
Sep-03	27.52	26.99	27.41	26.81	27.20	28.87	28.89	26.16
Oct-03	29.28	29.17	29.06	28.50	29.56	28.00	29.54	26.89
Nov-03	29.09	28.56	28.74	28.48	29.06	29.87	29.28	27.20
Dec-03	30.21	29.51	29.36	29.34	29.88	30.32	29.81	28.31
Jan-04	31.52	30.68	30.82	30.30	30.91	31.28	32.56	30.31
Feb-04	30.94	30.09	30.62	30.78	30.84	31.91	31.72	30.67
Mar-04	32.96	32.69	31.59	31.04	33.57	31.89	33.73	32.13
Apr-04	32.85	32.04	32.07	32.16	33.14	33.91	33.05	32.50
May-04	35.84	36.52	35.44	35.56	36.94	36.16	36.24	34.72
Jun-04	35.20	33.68	34.70	33.90	36.11	37.15	35.74	34.11
Jul-04	37.30	36.64	35.86	35.83	36.92	36.90	36.46	35.51
Aug-04	42.44	41.44	40.63	39.68	43.22	38.64	41.82	38.84
Sep-04	43.17	41.37	41.03	40.14	43.00	41.37	41.39	39.91
Oct-04	47.34	46.32	45.85	44.53	47.85	40.34	47.54	44.42
Nov-04	42.73	40.73	42.04	40.82	41.80	41.89	46.74	40.89
Dec-04	38.80	37.07	38.78	37.58	38.45	39.08	41.04	35.67
Jan-05	41.88	41.01	40.03	39.49	42.95	39.14	40.68	37.19
Feb-05	43.85	42.82	43.05	41.00	44.60	41.48	43.16	39.58
Mar-05	50.51	49.68	49.11	47.53	51.48	44.31	49.02	44.77
Apr-05	50.05	49.20	49.18	48.58	49.65	50.42	50.41	45.89
May-05	47.45	46.45	46.33	44.85	47.47	50.74	48.85	43.79
Jun-05	51.41	52.05	50.24	49.03	52.70	50.51	50.26	47.98
Jul-05	56.21	56.10	53.94	54.39	57.40	54.63	54.19	52.43
Aug-05	61.12	60.90	59.04	58.05	63.58	56.97	59.69	56.69
Sep-05	61.45	60.97	59.08	59.30	61.78	60.16	61.96	59.39

Figure 21. Average Crude costs

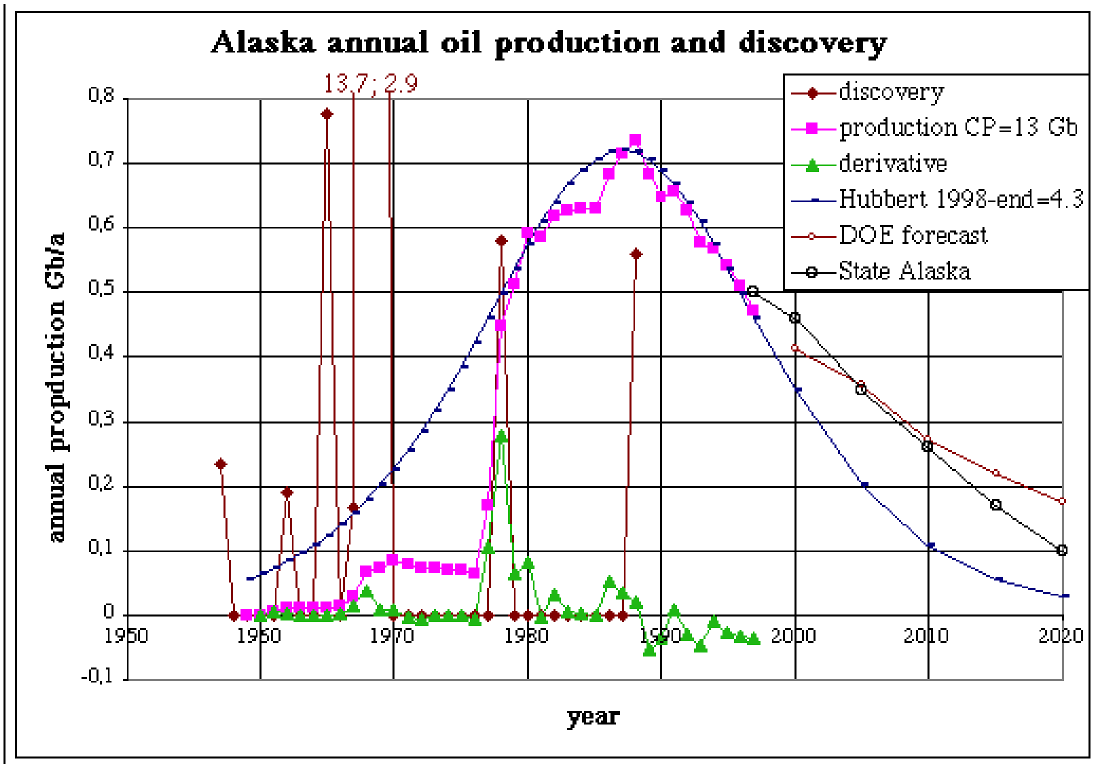

Figure 22. Alaskan Oil vs Hubbert (Poisson distribution)

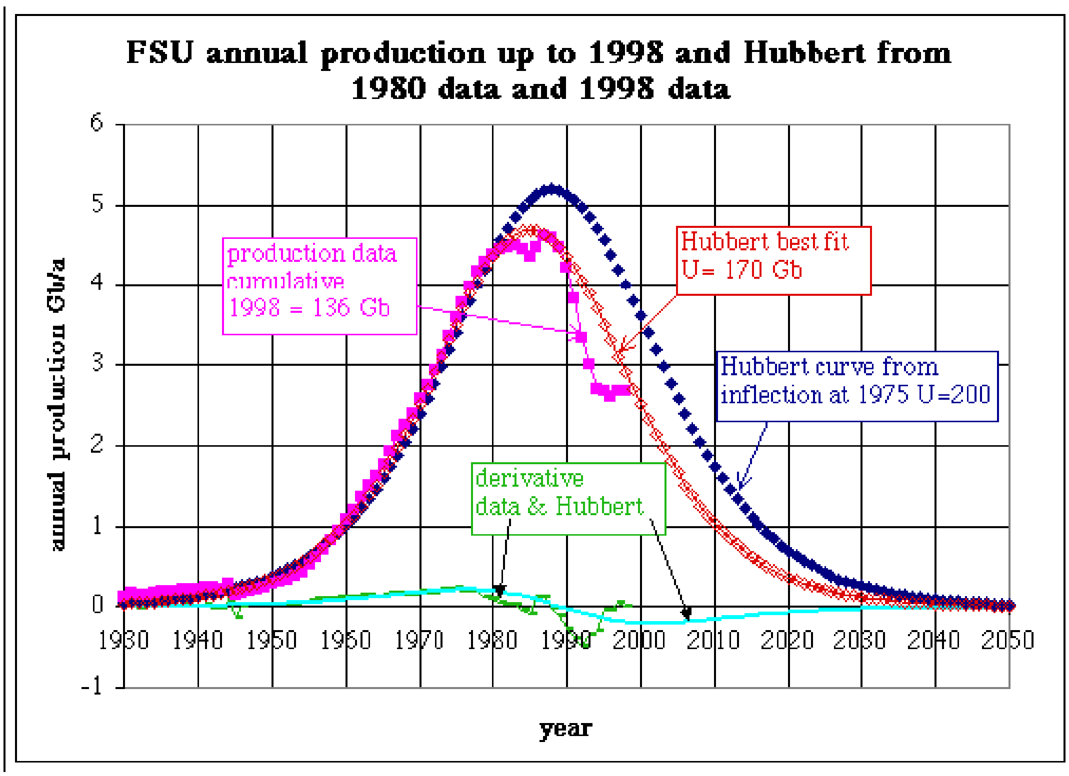

Figure 23. FSU Oil vs Hubbert (Poisson distribution)

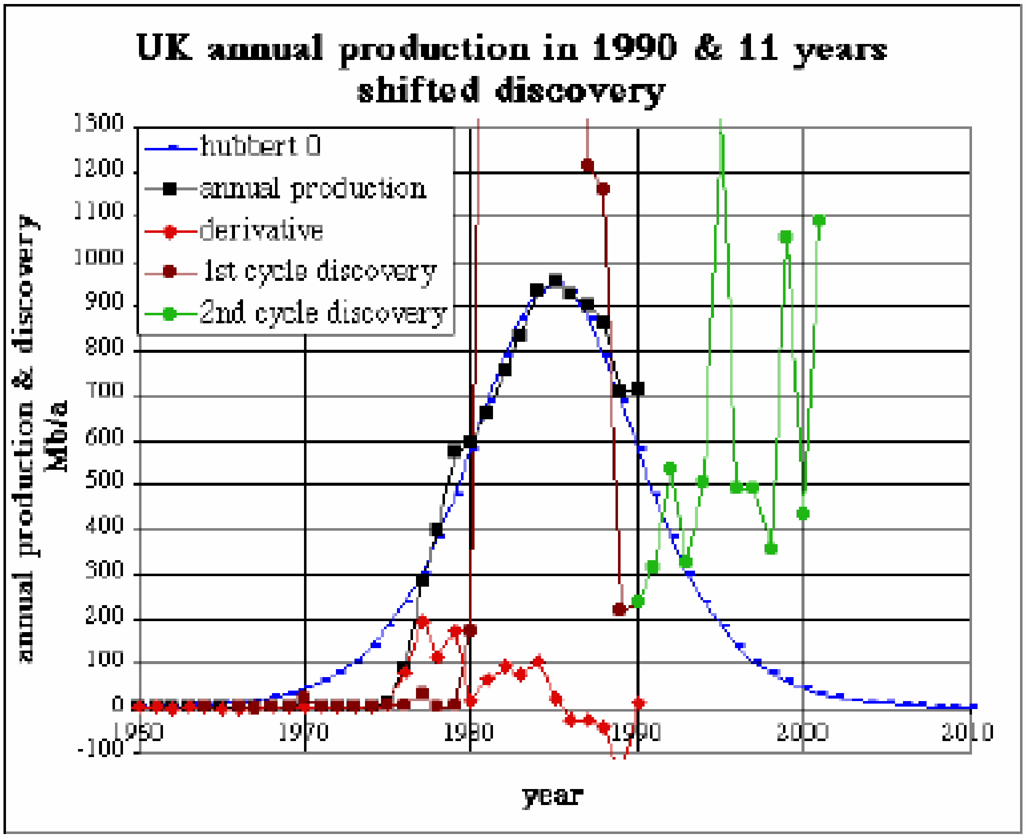

Figure 24. UK Oil vs Hubbert (Poisson distribution)

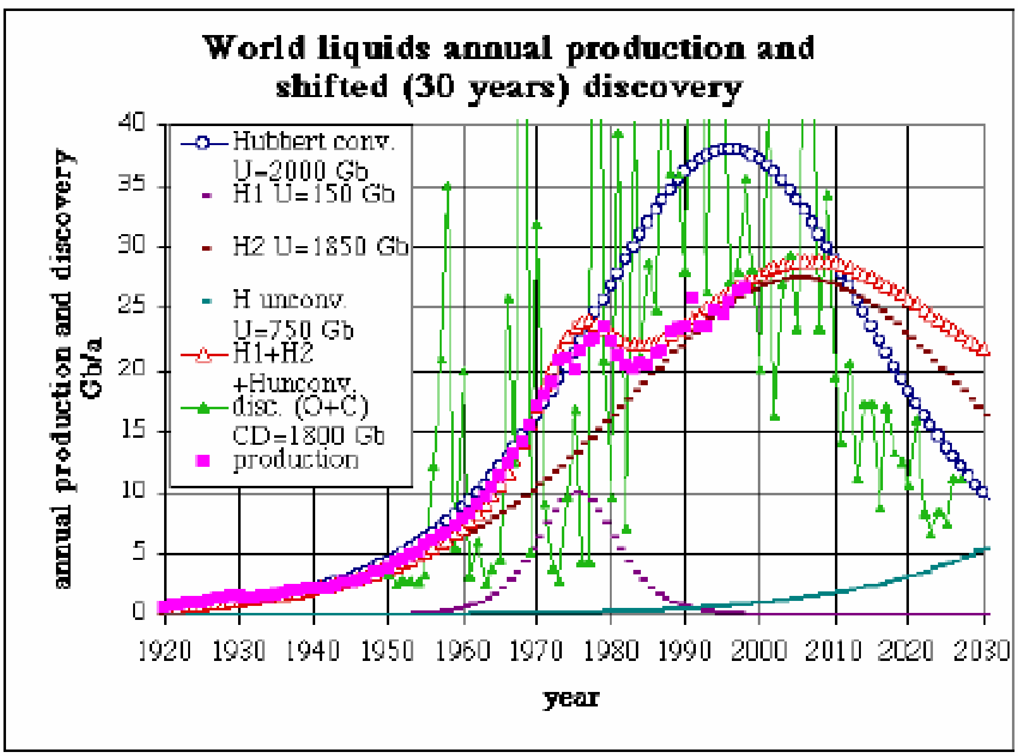

Figure 25. Global Oil vs Hubbert (Poisson distribution) and shifted discovery rates

Summary

A peak in liquid hydrocarbon supply will occur at some period in the foreseeable future, and a decline in production rate will follow. Demand destruction is possible only within the discretionary areas of liquid fuel energy use which will have adverse impacts to the global economy and commercial aviation if not effectively countered by proactive management. Economy of operation in the short term is rather limited in scope, but measures are available to be implemented. Future improvements are evolutionary in the main rather than revolutionary, with air transport remaining an energy intensive mode of transport.

Unconventional oil has significant environmental constraints to widespread introduction, and in the main limits to production capacity that do not mitigate the loss of oil production. CTL is viable at current costs, but requires technology validation of sequestering of CO2 to be implemented without severe environmental impact Production volume is not restricted other than by investment. GTL is a stop gap measure, with similar CO2 constraints as CTL. Production life is constrained by increased demands for depleting supplies of gas.

Failure to manage peak oil has potential to be a significant risk beyond commercial aviation, and can potentially affect viability of civilization due to non linear responses of the population as a result of a failure of confidence.

In the absence of evident substantial activity in the industry to diversify fuel supplies, it appears that time to respond effectively is becoming limited, if not inadequate to avoid adverse impacts.

Australia’s existing population program is inconsistent with a world of scarcity in basic resources; liquid fuels, food and water, population exacerbates the supply/demand imbalance implicit in peak oil.

Australian existing defence structure limits reserve capacity to protect resources.

Conclusion

Action to date to protect commercial aviation from the effects of peak oil production does not appear to be consistent with the seriousness of consequences from failure to manage the situation.

Solutions for improving efficiency in the industry are possible but generally limited in effect, and will not significantly impact the outcome.

Lead time for effective diversification of fuel supplies to manage oil depletion is substantial, and if preventative measures are not initiated in adequate time, the economic impact to the aviation companies may preclude an acceptable outcome.

A failure of the commercial aviation industry will have severe flow on consequences to global economics, as obviously is the corollary.

A failure to respond by government and industry in structural ways increases potential for serious consequences, and ensures any positive outcomes are lost.

Climate change and inevitable energy constrains do not favor delayed or timid responses for the long term viability of humanity.

“Hello, Houston, is anyone there…?”

Monday, 10 April 2006
Christophe de Margerie, head of exploration and the likely future chairman of TOTAL, has acknowledged that oil production capacity will never reach the huge targets forecast by the international Energy Agency.

From the UK Times:
http://www.timesonline.co.uk/newspaper/0,,175-2124287,00.html

The world is mistakenly focusing on oil reserves when the problem is capacity to produce oil, M de Margerie said in an interview with *The Times*. Forecasters, such as the International Energy Agency (IEA), have failed to consider the speed at which new resources can be brought into production, he believes.

“Numbers like 120 million barrels per day will never be reached, never,” he said
In a second more detailed interview de Margerie acknowledges peak oil:
http://business.timesonline.co.uk/article/0,,13130-2124075,00.html
"People are failing to deal with the reality of the price, which has nothing to do with speculators or even any lack of reserves, which are ample. **"It is a problem of capacities and of timing," de Margerie says. "This is the real problem of peak oil."**

The IEA has predicted that the industry needs to produce 121mbd of oil by 2030 to meet growing demand. TOTAL's frank dismissal of this possibility falls in with Chevron's acknowledgement of the difficulties of increasing oil production bu huge amounts. Both are in sharp contrast to Exxon Mobil's recent ads claiming there is "**no peak in sight** ".

March 9, 2006

Mr. Rex Tillerson
Chairman of the Board
ExxonMobil
5959 Las Colinas Boulevard
Irving, Texas 75039-2298

Dear Sir:

I am very pleased with the Ad your company placed in the media on March 2, 2006. It is a relief to know that "Peak Oil" is not a problem. A peak, ExxonMobil claims, "will not occur this year, next year or for decades to come". Technology will save us by consistently increasing the estimates of recoverable oil. ExxonMobil's Ad tells us that "oil production and production capacity have increased", and there is "enough potential supply to meet .. demand".

ExxonMobil obviously has inside information it does not want to share with the public. We are thus forced to take the implications of your company's Ad at face value. Based on representations made by ExxonMobil, I can keep my SUV and buy a motor home. I no longer have to worry about oil shortages. Your company's Ad infers there will be plenty of gasoline for the rest of my life, and of course, with such a plentiful supply – it will not cost much. Lord knows, with the profits your company made in 2005, there is no need to raise the price of gasoline, diesel, or heating oil fuels.

Unfortunately, there appears to be a discrepancy between the wonderful optimism of ExxonMobil's Ad, and the reality of your operations as reported to the American Securities and Exchange Commission (SEC) on form 10K. Now don't get me wrong. I am very sympathetic with your company's desire to project a positive image to investors. But can you explain why ExxonMobil's Net Proved Developed and Undeveloped Oil Reserves, and Net Productive Oil Wells have declined, or why almost all of the reserve additions made in 2005 were in the form of natural gas – not oil. And if most of ExxonMobil's production revenue is coming from oil and NGL, and oil reserves are decreasing, is it possible ExxonMobil is eating up its oil reserve legacy? And if there is so much oil out there, why isn't your company's oil business growing?

Frankly, Rex, the reality of your company's oil business appears to be at odds with the very bullish image projected by ExxonMobil's Peak Oil Ad of March 2, 2006. If the largest independent oil company in the world is experiencing reserve growth challenges, that fact raises serious questions about the entire independent petroleum industry. Consequently, your company's "Peak Oil" Ad is nonsense.

Well. I'll say goodbye for now. Keep on drilling them holes.

Ronald R. Cooke
The Cultural Economist
Author: Oil, Jihad and Destiny (A book you should read).