The Coming Energy Winter:

II. Resolving Uncertainty about the Oil Peak

Brendan McNamara
Leabrook Computing, Bournemouth
brendan@leabrook.co.uk

November 15, 2004, Ver. 1.2

I. The Oil Peak Controversy 2
I.1 Real Events 2
I.2 Good and Bad Outcomes 3
II. Uncertain Predictions 3
II.1 ASPO on Peak Oil 3
II.2 USGS Survey 2000 of Global Expectations 4
II.3 Market Driven Extrapolations 6
III Unintended Consequences 7
III.1 Probability and Risk 7
III.2 Three Mile Island – An Archetypal Disaster 8
IV Energy Crisis Probabilities. 9
IV.1 A Coming Energy Winter 9
IV.2 A Managed Transition to a Sustainable Future 10
Acknowledgements 10
Author 10
References & Reading List 11

I. The Oil Peak Controversy

There is a great controversy over the future of oil and gas which is so important for our whole civilisation that we must get it resolved soon. It is certain that the supply of cheap, conventional oil will peak and decline this century and the world economies will have to change forever to more expensive fuels, but the argument is about when the peak will come and decline set in. The difficulties lie in the data on oil and gas discovery, exploitation, and production because the data is unreliable, needs interpretation, and must then be modelled wisely to predict the future. We will show that none of the current prognostications is really sound. An independent multi-national effort is needed to develop reliable predictions from existing data that will resolve the uncertainties and allow for clear political action.

The predictions run from a peak by 2010 from ASPO [Association for the Study of Peak Oil , www.peakoil.net], based on an understanding of what is in process now, to a peak in 2035 by the USGS [US Geological Survey, pubs.usgs.gov] based on hopes of a higher percentage of oil to be extracted and much more to be discovered, through exaggerated versions of these optimistic studies, all the way to absurd views of ever expanding energy supplies as science, invention, and engineering provide whatever we want [Odell]. The resolution is really about the timescales for events: When are resources discovered, at what rate could they be extracted, and how quickly can transport and processing infrastructures be put in place? The critical period is the next 25 years when all the important alternative energy programmes must be set up and running to handle the transition to sustainable energy supplies. The impact of the resolution depends entirely on human behaviour in a destabilised world.

It has not been in the pragmatic interests of countries or corporations to reveal everything about their energy resources, so underestimates, exaggerations, inventions, and secrecy are all recognised as part of the information flow. There is no single global data repository, though the Swiss firm, Petroconsultants, now owned by the IHS Group in Colorado as IHS Energy, is the world leader in gathering data for the industry. Other major sources are the Oil and Gas Journal, World Oil, and the annual global review by BP. None of these organisations provide any modelling of future supply.

I.1 Real Events

It is also not in the interests of any country to open all its resources to the world markets and pump at the maximum rate for immediate cash – why sell everything at $10/barrel when it will be worth $50 later? This was done by the UK government as the North Sea revenues were needed to support conservative social engineering. Norway was more prudent. The North Sea is now in terminal decline and will be essentially finished by 2020. It might seem sensible for any country to withdraw from the world market when its resources drop below 20 years of its own consumption rate, but the North Sea is still sending 1.7 million barrels a day to North America while their global exports are 0.4 Mb/d. In fact, some 36 out of 52 of the world's producing countries will be almost out of the market by 2020, including the EU, Indonesia, and the USA. Oil and gas contracts should now be like employment contracts – short term, without benefits.

The Islamic crescent from Morocco to Iran contains 40% of world reserves and probable new discoveries. It is a politically unstable region and a great source of disinformation. There are suspicions [Simmons] that the 260 Gb reserves reported by Saudi Arabia is overstated, although the USGS suggests there may be more there than even they state. The Saudis attempted to clear this up at a recent Washington meeting by announcing they could pump 10, 12, or even 15 million barrels a day for 50 years, lowering the probable range to between 180 Gb and 270 Gb (Gb – billion barrels). Mr. Husseini, ex V.P. of Saudi Aramco is warning that they did a thorough job on exploration and that outside estimates for discovery are far too optimistic, not only for Saudi but for every other region. For those still worried, the matter has been further clarified by Mr.Saleri of Aramco, who states that the sum of Proved, Probable, Possible, and Contingent reserves is now 600Gb. Confused? Of course.

What is true is that all these big suppliers have only one valuable resource – their oil and gas – and no more than 50 years to build stable and sustainable societies which could continue to flourish after oil. Since most of their earnings are in dollars, the recent 25% devaluation of the dollar has wiped billions from their net worth and helped push the oil price above $50. Financial policies surrounding oil need to be rebalanced.

The Mexican oil company, Pemex, has recently claimed there may be 56 Gb of oil in their portion of the deep waters of the Gulf of Mexico – presumably to stimulate rapid inward investment. This doubles even the USGS guesstimate of 54Gb for both the US and Mexican parts of the Gulf.

Nigeria is trapped in a cycle of corruption fuelled by UK, US, Chinese, and other clients, their banks, and institutions. Corruption may seem like a cheap way to control their huge oil resources but, with a population of 167 million with a median age of 18, political instability is a major obstacle to business, as Shell discovered. Similar considerations apply to Angola, Equatorial Guinea, Chad – the whole West African oil province.

Politics has a major impact on what resources can be accessed and developed, and even on which areas can be explored. Most of the world's oil lies in developing countries with all their variability. Any evaluation of the future of oil must include realistic political analysis and find ways to stabilise the flow of benefits for producers, oil companies, and end-users.

The story of Natural Gas is entirely similar but, having emerged later as a major fuel, the peak will be about 20 years later. There is a significant difference however. The gas is much harder to transport, needing large pipelines from remote places, crossing many countries with their cumulative difficulties, and then needing Liquefaction to transport by sea to LNG ports. North America seems to have gotten itself into a trap of having too few LNG ports, not enough tankers, and a rapidly falling gas supply. This lack of infrastructure can create huge shortages of a very large global resource [Darley] Refrigerated gas reserves are expensive to maintain, so Europe runs on continuously pumped supplies which are exposed to all kinds of interruption.

I.2 Good and Bad Outcomes

There are many bad outcomes possible if the right predictions are not made, including war, financial collapse, the failure of intensive agriculture, starvation, disease, and even a massive die-off [Howe]. An overriding consideration is that global warming can only be reduced by curbing our use of Carbon fuels. A 1000 megawatt nuclear power station makes about 200 tons of radioactive waste per annum, but an equivalent coal station throws 3 million tons of carbon dioxide into the atmosphere. Thus, an ever increasing supply of carbon fuels is wholly undesirable anyway.

Good outcomes can be managed even under the predictions of an imminent peak and decline. About 50% of our energy output is simply wasted, so similar living standard could be maintained with less. Building new energy, transport, and manufacturing systems will keep economies vibrant for a century.

The human behaviour which leads to triumphs or catastrophes needs to be understood and modelled into our predictions. In the 1980s Reagan and Bush slashed energy research programs by 70% in favour of hugely increased military spending and the ineffective science of Star Wars. As lots of oil was being discovered in that period – including the North Sea – most other countries followed suit and even closed their Departments of Energy. Japan was a notable exception. These blunders mean that these governments have been running blind on energy, with guidance only from small academic groups and environmentalists.

Bad news is never popular, but political inaction till the moment of clear and present danger is just a gambler's folly. Nevertheless, fear is an excellent motivator to finding better solutions, though pre-emptive war does not seem to be one of them. Let us compare the realistic, optimistic, and fantasy predictions:

II. Uncertain Predictions

II.1 ASPO on Peak Oil

Most oil fields are already in decline – the USA having peaked in 1971 – and, based on all discoveries to date, amounting to about 2.2 Trillion barrels of oil, the total supply from these sources is about to peak. This is the prediction of ASPO and many others [Links on excellent US site - www.peakoil.com]. The focal point for their work is not the total global endowment, but how it is likely to be produced and, like any finite resource there will be peaks and declines. Their model is straightforward: On average, when an oil province has produced about half its recoverable oil, decline sets in at something like the peak pumping rate achieved. Gas is different as the peak is at the 80% depletion point followed by a very rapid decline. The models are not connected self consistently to the economics of exploration and production, or to the politics of the oil provinces, so the real historical parts are jagged and the computer generated projections are smooth.

The defect of their work is just due to the small scale of their available effort, which focuses on the history and geological prospects of each producing nation, using IHS Energy country data [Bentley]. Their model results are shown below:

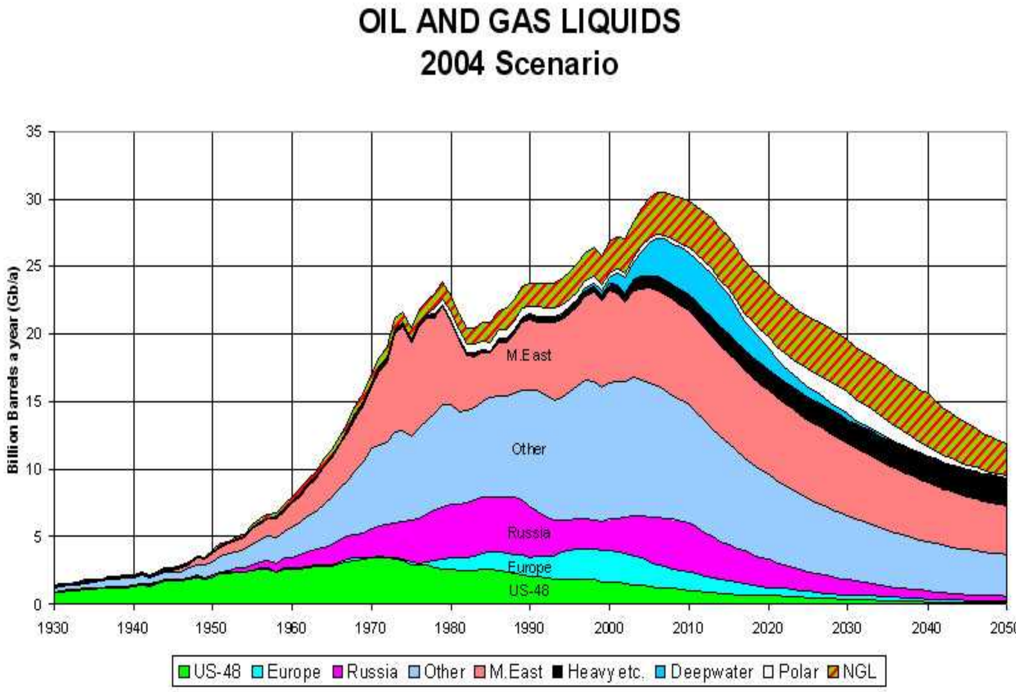

Fig II.1 The peak of conventional oil supply is now predicted to be at 2008. The US, EU, Indonesia, and many others will be almost out of oil by 2020. Total supply will be less than today by 2020. (ASPO)

II.2 USGS Survey 2000 of Global Expectations

In 2000 the US Geological Survey (USGS) released a detailed global study which claims that a 'Reserve Growth' of a further 0.4 Trillion barrels can be extracted from existing oil fields and that 0.6 Trillion barrels remains to be discovered. It is extremely valuable, and typically American, to run a pro-active, highly optimistic project to evaluate our global prospects for oil and gas. All government policies since then have been based on these happy predictions, but which only puts the peak out at 2035 at a production rate 70% greater than today's.

The actuality is that none of this extra oil is yet turning up, and may not turn up in time even at the current oil prices of $50/b and improved levels of exploration and field development. The world is now using about 28 Gb of oil a year, far in excess of the discovery rate of 10-12 Gb/a . Production has exceeded discovery for 20 years, a grim fact, confirmed by IHS, which outweighs all prognostications, statistical models, and educated guesswork on the future of oil.

The treatment of Reserve Growth is one of the slipperiest and most uncertain parts of the argument [Harper]. True Reserve Growth should be defined as new discoveries in the same oilfield structures or as extra oil extracted by virtue of new technologies, but not as oil from known oilfields which have not been previously exploited. It should not include New Discoveries in some distant part of an oil Province or simple updates to a database. However, these niceties are rarely observed and the average perceived growth is far greater than the real growth. The perception should not be applied as a global multiplier.

New fields discovered this century are unlikely to see large growths because the full weight of modern seismic technology is routinely applied in the discovery and evaluation process. The USA has drilled over 400,000 wells in the last century, but discovery of smaller fields by drilling is not so easy in remote, polar, or ocean shelf regions. The American experience of Reserve Growth, on which their estimates are based, merely extended the tail of decline. The Islamic Crescent only has 6300 wells so, on drill count alone, there would seem to be a lot more yet to be found in accessible territories. Politics will have far more to do with production there than will technology and should be modelled in various scenarios to get realistic predictions.

There are many doubts about the expectations for new discovery. The USGS has boldly made strong predictions about many regions but the big oil companies are hardly leaping on their suggestions. The USGS has made a sterling effort to ground heir work in geological assessments. However, each final estimate is based on a low value at 95% probability and a frequently very high value at 5% probability. The figures used are then the mid point of these estimates – the 50% mark. The same argument for a lottery runs as: There is a 1% chance of winning $5 and 1 chance in 10 million of winning $20M, so there must be a 0.5% chance of winning $10M. Most punters are even more optimistic and continue to hope for the $25M. There are many deluded oil analysts who feel that the 5% USGS possibilities can be achieved by investment and market pressure, even if they do not exist.

The common hope for finding a 200Gb province around the Caspian sea has been disappointing with only a very acceptable 70Gb identified. It will take several decades to complete detailed exploration of the region, and these timescales have to be factored in.

Finally, in 2003, Canada declared their huge tar sand deposits to be equal to Saudi Arabia as a source of oil. However, sand mining and thermal processing to extract the 10% or so of bitumen is very slow and expensive. The natural gas equivalent of one barrel of oil has to be used in the processing and hydrogenation of the bitumen to make three barrels of sweet crude. Canada hopes to make 4 Mb/d by 2020, if the gas is available. The tar sands will make only a small contribution in the next 25 years.

Here is the known data, prepared by Stark and Chew of IHS Energy, incorporating the USGS predictions on Reserve Growth and New Discovery:

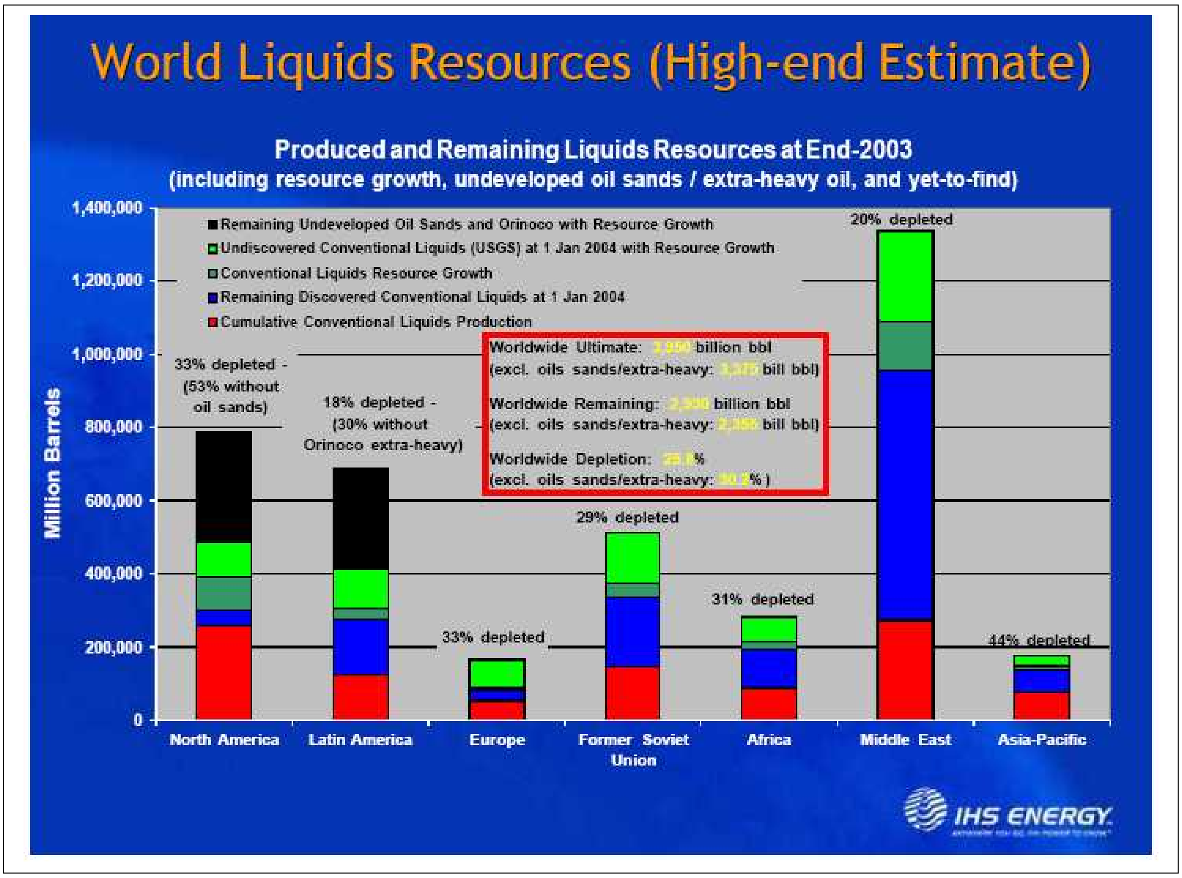

Fig II.2. Ken Chew's assessment with IHS data, using only 20% estimates of Reserve Growths, includes Undiscovered liquids, Tar Sands and Heavy Oils. (Inst. Energy Conference, London. Nov 10, 2004) Previous 2003 version can be found at:

[http://www.ihsenergy.com/company/events/presentations/usgs_resources.pdf]

This is the sort of chart Enron might have shown to their investors – persuasive but incomplete. These bar charts contain no timescales and no attempt has been made to project even the next 25 years. It is the newest and most conservative of all the high end projections. Their Low End projections are close to the ASPO figures.Let us list some more of the HIS presentation and reservations about this new view of their database:

- The heavy oils of the Orinoco are hardly touched. Tar sands will not be a serious supply till the latter half of the century. So, we should think more about 2355 Bb and trying to sustain 100 Mb/d for 60 years.
- The US EIA claims up to 7500 Gb for heavy oils, tar sands, and oil shales, but Chew has only assigned 575 Gb as possibly recoverable. Excellent but only enough for 20 years global needs or 100 years for the USA.
- The previous version of this chart – to end of 2002 – had 130 Gb less conventional oil in the Middle East. No explanation.

- The US Reserve Growth is shown to be still 200% larger than the remaining discovered liquids. Presumably this reflects the expectations for growth of current finds in the Gulf of Mexico.
- All the undiscovered North American liquids are in the arctic, the Gulf of Mexico, or the continental shelves and deep ocean margins. This can only help slow the decline, slowly.
- Europe will be almost dry of oil by 2030. The hoped for discoveries are off the East coast of Greenland, but nobody is looking at present deep in the Arctic Ocean under a kilometre or more of ancient lava.
- The FSU is back in production after Gorbachev dismantled the USSR. The Caspian finds are good but the remaining prospects are in arctic regions. The FSU gas reserves are much larger.
- The Middle East is slated for 300Gb of new discovery, but the Saudis are much more cautious. The total P2 (proved +Probable) is lower than Proved from other sources. To push world production to 120 Mb/d by 2030, as economists would like, the M.E. would have to quadruple production [Smith] – a rate unacceptable to them.
- The current data shows 464 Gb more oil in 1994 than was in the database at that time. Revisions, underreporting, unreported oil fields, the tar sands, and some real Reserve Growth of about 190Gb account for this huge hole in the accounts.
- The whole story seems to be falling apart on discoveries. The peak of discovery was in 1965 but the number of finds in the 1980s was double. Unfortunately, the total volume was 1/3. The downward trend continues and only a couple of the USGS 50% predictions are coming through. Some smaller plays have been better than expected.
- The USGS expected 240 Gb to be found since 1995 but only 109 Gb has been discovered.
- On the positive side, the IHS have given no credence to Wyoming oil shale or deep ocean methyl hydrate suggestions.
- An IHS Energy analysis of petroleum trends for 1994-2003 matches the ASPO position for conventional oil and gas, and says 65% of giant 2003 discoveries were offshore below 1000m. [http://www.ihsenergy.com/company/press/pressreleases/arc2004/trends.pdf]
- Chew expects there to be problems meeting demand between 2011 and 2020.

Let us make prudent adjustments to the projections: Drop the tar sands – 600Gb; halve the Reserve Growth – 200Gb; and halve the new discovery – 300 Gb. At a steady 100 Mb/d the estimated 1855 Gb of oil would last 50 years and stop dead one Friday afternoon. A sensible model would show a rise to a peak and a steady decline with rising prices for the rest of the century.

II.3 Market Driven Extrapolations

Here are some extrapolations of the USGS model from the WETO Report for the European Commission. It is possible that supply could be increased steadily by over pumping all oil fields, but then the crash in the 2030s would be precipitous. Economists, with little real appreciation of oil or technology, base their modelling on the notion that markets create desired results, like rubbing a magic oil lamp.

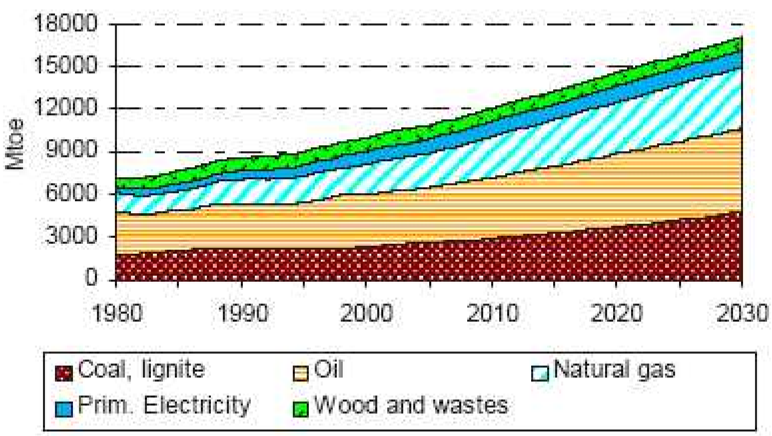

Fig. II.3 Simple world energy projections at 1.8% pa with growth on demand and no supply or ecological restrictions. Oil use grows by 50% and gas by 200%. Prepared for the EEC by the WETO group.

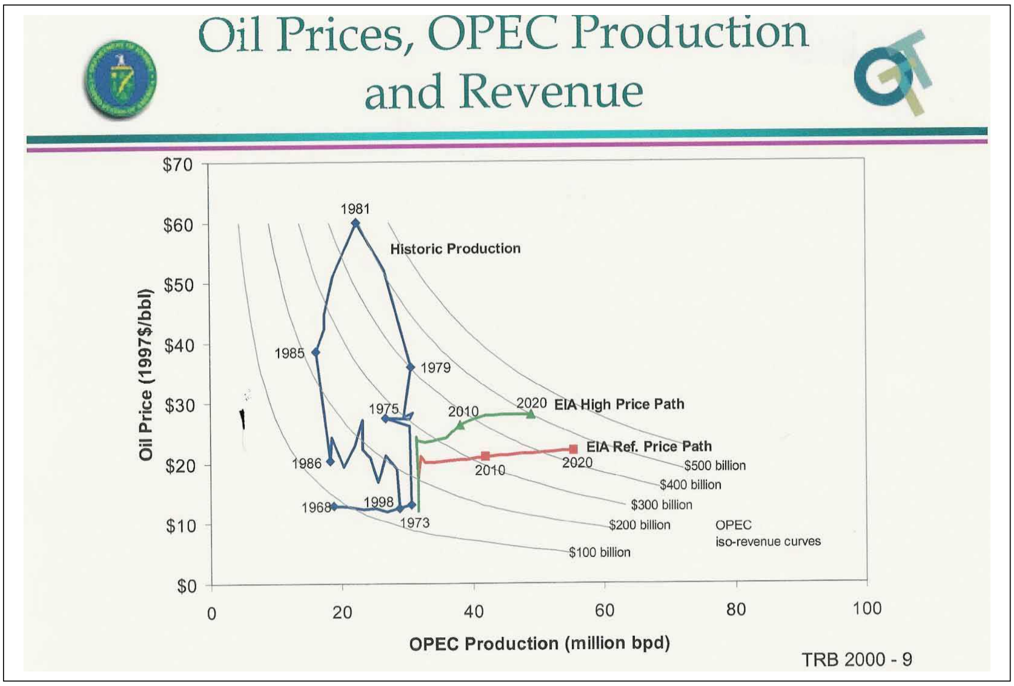

Fig II.4 Absurd projections by the EIA typify a lot of the thinking behind Western energy planning. The historical chaos shown was due to political blunders, not real supply difficulties. The future projections are smooth and shallow and already wrong.

The absurdity of this type of modelling is illustrated by the 2000 chart above from the US Energy Information Agency, which likes to use jackpot numbers. The historical part of the chart shows the huge gyrations in OPEC price and production, but the projections are fantasies about 50 Mb/d from OPEC by 2020 and a steady price for oil over the next 20 years. The World Energy Council report for 2004 accepts much of the ASPO position if the total resource base remains around the 2200 Gb level. By 2030, they say most of the expected production will come from 'capacity yet to be built'.

These discussions show that none of the projections can yet be trusted as a basis for energy policy. The USGS presents the best that could possibly happen but this should not have been built upon further in making policies that have placed all the bets on this being true. The IHS review is the most prudent high end statement and clearly indicates caution in simply ramping up production to meet demand. Already, 85% of known reserves are now in production as oil companies work through their inventory in the absence of major discoveries. Experts, Agencies, Councils, and consultants engaged in uncritical and ill-informed behaviour have discredited themselves. We now move on from technical questions to consider how 'the best laid plans of mice and men gang aft a-gley' (Robert Burns). Simplified analysis of a real disaster provides a framework for predicting the future:

III Unintended Consequences

Systems are designed to produce a good outcome with a very low expectation of a bad outcome. Disasters are usually found to depend on the confluence of a whole series of supposedly rare events rather than a single point of failure. To understand how they happen we must know a very little about probability theory:

III.1 Probabilit y and Risk

The probability, p, of throwing a six with a perfect dice is $P_6=1/6$. The probability of throwing two sixes with a pair is not the sum of the probabilities but the product, $P_{66}=1/36$. It is this multiplication of probabilities that makes the chances of any long sequence smaller and smaller. With really careful engineering, a spacecraft like Cassini can travel a billion miles to return flawless pictures of the moons of Saturn because every component has a tiny probability of failure and key components are duplicated. Expert humans are not that good and the best we can expect is a 1/1000 chance of a serious mistake, which is why there are always two pilots on passenger jets, bringing the failure prospects down towards 1 in a million. In a political or social system, where the 'engineering' is laws and regulations, one would hope that there are enough checks and balances that major disasters would be unlikely - holding world wars down to only two last century.

The reason that social systems are so unreliable is that human probabilities are also dependent upon each other – magnetised dice would always throw only six combinations. One powerful opinion can override all others and one loud, absurd person can give pause to the others. Equally, a single sharp move in the right direction can turn the whole herd. (It is possible to analyse expert opinions, by statistical sociological methods rather than mere prejudice, to identify those who are reliable. [Szwed, van Dorp])

Big risks can be analysed by working back through all the possible pathways and multiplying up the probabilities. Other risks can be discovered by starting with one failure and branching up the tree. Now multiply the nominal value of the risk by its probability on each path: If this is ever greater than unity then one must either find a way to decrease some of the probabilities in the chain, or walk away from the situation to eliminate the risk. Unfortunately, one or more probabilities may change without your knowledge – especially if a human is involved. A further innocuous step can trigger disaster. Here is how it can happen and why hindsight is not required:

III.2 Three Mile Island – An Archetypal Disaster

A classic energy disaster that brings all these considerations together arose from the reactor meltdown at Three Mile Island, 28 March, 1979. The annual probability of such an accident should have been – for illustration purposes - about 1 in 100 million, $P_{meltdown} = 10^{-8}$, but the Nuclear Regulatory Commission [NRC 1979, World Nuclear association 2004, Other Websites] was running very light inspections. This allowed the management to falsify reporting on maintenance problems that would have triggered NRC intervention. The staff were poorly trained, with an error rate far above 1/1000. The reactor design by Babcock and Wilcox had many design faults, especially in assumptions about how well maintenance would be carried out. Since the effects on safety are not cumulative but multiply together, the real $P_{meltdown}$ was more like 1 in 100 thousand.

The reactor cooling had four systems: The primary water circuit through the reactor to a heat exchanger, a secondary steam generator circuit from the heat exchanger to the turbines, a pressure release and storage system for the reactor when it overheated, and an emergency cooling backup for the reactor. Months before the accident the pressure release valve accumulated deposits which would prevent it closing again after opening. Worse, the only operator's monitor for this valve was a check that the actuator had been set to open or closed, not that it was actually opened or closed. This constituted a single point of failure in the emergency systems, undetected by maintenance. Unknown to the operators - $P_{meltdown}$ was now about 1/1000.

A few days before the accident some valves were closed for maintenance work in the emergency cooling system and the team 'forgot' to re-open them. Worse, some handles and actuators had been removed and not replaced. Unknown to the operators, only one more error was needed to crash the system. $P_{meltdown}$ was now about 1/100.

On the day of the accident 'something' happened during maintenance work on the steam system – a something which the NRC has never found or stated – and the secondary shut down and stopped the turbines, exactly one year to the hour from the initial startup of this reactor. With the emergency systems disabled, meltdown was now inevitable. The reactor circuit was no longer being cooled by the secondary and the reactor, running at a full 909MW, was automatically scrammed by the insertion of all its control rods. Unfortunately the fission decay products still produced a lot of heat and the reactor soon boiled. Within five minutes, the Pressure relief valve opened briefly but only closed partially, allowing the coolant to leak out steadily. It took hours to get the emergency pumps working, so the top of the reactor boiled dry and melted.

The emergency pumps continued to supply water which leaked for over two hours before the operators closed the relief valve manually. Enough cooling was used to prevent total meltdown and any breach of the containment systems. Some radioactive coolant did escape, but a major radiological disaster was avoided.

This did not prevent CBS from broadcasting a panic report that radiation was intense inside the plant and measurable a mile away, a normal wild extrapolation of the truth by US media. The State Governor ordered the evacuation of all women and children from the area. All of the injuries from the incident occurred in flood of escaping people, though no one sued CBS or the Governor for their irresponsibility.

The Three Mile Island owners may have been pleased that they had survived a meltdown without massive loss of life. However, they effectively lost the whole US nuclear industry and no new reactors have been built since, a $100Bn disaster much greater than the accidental loss of a single $3Bn reactor.

All the faults that lead to this accident, primarily human error and a failure at every level for people to do their jobs conscientiously [Simpson], are entirely avoidable but the NRC and politicians of the day were unable to put it in context and change regulatory procedures sufficiently to satisfy public opinion. This was the real Three Mile Island disaster and a risk which had never been appreciated. Modern computer science is well able to model such scenarios – there is enough history to make hindsight largely unnecessary.

France has the best safety record in nuclear power. Perhaps the EU should ask them to host a new round of nuclear stations.

IV Energy Crisis Probabilities.

The reporting and analysis of oil and gas data is sufficiently chaotic that we have good expert opinions which range over pessimistic, realistic, optimistic, and fantasy positions, fantasy being preferred by most governments. The oil companies and engineers have done a truly magnificent job in supplying the world with fuel, but it is governments' responsibility to monitor and plan our energy resources. The BP 2003 Statistics show only 16 countries out of 53 with a Reserves/Production ratio greater than 20 years. The critical period for which the analysis **must** be correct is the next 25 years.

IV.1 A Coming Energy Winter

The risk to be analysed is that the world will continue on the present path and be economically and politically shocked by an unplanned, strong (3-6%) decline in this period. Let us list the events that have increased the probability PSHOCK of this:

- **Energy Research:** Funding slashed by 70% by Reagan and Bush in the 80s. Predictions of Peak by 2000 refuted. Global Recession slowed consumption, averting peak. UK and others closed their Departments of Energy. PSHOCK Doubled.
- **Fusion** Downgraded: Reagan sequestered funds and scientists for ineffective Star Wars initiative. Still not reinstated.
- **Oil and Gas Discoveries**: Surge of discovery in 80s confirmed optimism and energy research left at a low level. US oil independence continues decline. Analysis weakened. PSHOCK Doubled again.
- **Reactor Accidents**: TMI and Chernobyl stopped western reactor deployment. Coal power stations not replaced. Global warming continues. Energy independence forgone. PSHOCK Doubled again.
- **Offshore Oil**: Huge capital investments for North Sea, Gulf of Mexico, African, and others necessitate oil company mergers. New oil slower and costlier. PSHOCK raised again.
- **USGS Survey 2000**: Raised overall optimism, but no detailed modelling of supplies. Stimulating, but further amplified to fantasy by energy planners. PSHOCK Doubled again.
- **Global Warming**: Kyoto rejected by G.W. Bush. Restrictions lifted on Coal emissions, conservation measures relaxed. SUVs push waste of fuel higher. Globally, Energy planners proceed with unrestricted growth scenarios. PSHOCK Doubled again.
- **UK Energy Blunders**: North Sea oil dissipated onto world markets. New Energy Policy switches to gas as 90% of energy program. Abandons energy security. Coal under closure. Nuclear allowed to terminate. Wind power, a credible renewable energy technology, to be the only significant alternative. Conservation and transport initiatives founder. <u>A wider set of experts was needed and other views should have been published.</u> PSHOCK Doubled again.
- **US Natural Gas blunder**: Some 200 Gigawatts of new gas fired power stations have been built without a study of the security of gas supply. A local gas shock has been created for lack of LNG infrastructure [Darley]. PSHOCK =1 for US gas supply.
- **Developing countries** face declining fuel supplies merely through rising prices. For most of them PSHOCK =1.
- **No Super Giant Discoveries** this century (> 10Gb): PSHOCK Doubled again.
- **Iraq**: The war has clearly antagonised the whole Muslim world. Oil resources face increased political problems. PSHOCK leaps to 10%.
- **Terrorism**: Government focus on these issues reduces attention on all others. PSHOCK not improved.
- **UK Oil Peak Research** funding denied: There is no official research category for this activity. All recent project proposals have been rejected.
- **Media**: Continue with undiscriminating coverage of energy, including absurd schemes like Cold Fusion, space mirrors, and the like. Only clear position is hostility to nuclear power.
- **US Election**. The Bush win may well freeze global economic growth, which could be good for oil supply. PSHOCK reduced.

This list seems pessimistic but every item has had a real impact on the current perceptions of energy security. The probability of an Energy Winter is too great to be brushed aside. Let us conclude with a list of steps towards good outcomes.

IV.2 A Managed Transition to a Sustainable Future

Constructive works add to the economy so the processes of building completely new energy, transport, and agriculture systems will be a stimulus, not a loss. A decline in oil and gas supplies can be accommodated for 25 years through conservation and lifestyle improvements, but economic theory will have to be reworked to handle decline rather than endless growth. Unregulated free market economics clearly does not work [J. Stiglitz] as it takes no account of predatory human behaviour. Trivial analysis by spreadsheet is 30 years behind current computer science. The idea that markets will find solutions to major problems is wrong - they merely find the steepest paths to higher profits. It is the clear duty of governments to be responsible for our financial, health, and energy security and for making the long term investments needed.

Here is a short list of required actions to plot a new course to secure our near term energy future:

- Oil and Gas Review: This needs about EU5M for a thorough multi-national study of oil and gas supply leading to a consensus for the next 25 years.
- Subsequent efforts would evaluate and model plans and policies to deal with the consequences. The financial benefits should be regulated to provide more equitable shares among players.
- All governments should have Departments/Ministries of Energy to directly support research, development, and deployment.
- All government departments and larger companies should develop their own energy and transport conservation procedures. All cities should do likewise.
- The big hit of the Energy Winter will be on Transport. Natural gas should be converted to diesel fuel and the use of gas for electricity steadily reduced.
- Vehicle fuel consumption should be strongly regulated to decline. Most vehicles will have to be replaced within a decade – a magnificent boost to the industry.
- The new, safe, efficient nuclear power stations should be deployed in all G-8 countries.
- The Fusion program should be brought to fruition in this period. [McNamara]
- Wind and Solar systems should be vigorously, but sensitively, deployed.
- Industry should be de-globalised wherever possible. Local self-sufficiency is the goal.
- Developing countries deploy sustainable energy systems – wind, solar, and biomass.
- Industry must be regulated to reduce waste and stop production of goods designed to fail. All glass, metals, and plastics need to be recycled. Many European cars can now be 90% recycled, and run at 50-80 mpg, with service intervals of 18,000 miles. Few other consumer products come anywhere close to this.
- Food production must reduce its dependence on fertilizers derived from gas. GM crops really may be the only way to maintain production in the absence of energy intensive methods, though ecological impacts need deeper evaluations.
- Housing policy must be reformed to stress energy conservation. Local communities should be constructed with local shops, offices, schools, social amenities, community spaces, and industrial sites in walking/cycling size sectors - not dormitory housing for commuters.

There are many versions of these proposals, which should be implemented regardless of oil supply, global warming, or other environmental concerns, just to improve the average quality of life. My own expectation is that there will indeed be an Energy Winter of falling supply followed by a recovery to a long plateau of managed consumption while replacement systems are built.

Our civilisation cannot afford to gamble on our energy future. Uncertainties about the peaking of oil and gas must be resolved. In the meantime, buy oil shares.

Acknowledgements

I am grateful to Roger Bentley, Secretary of ASPO, for recent discussions on the interpretation of oil data. To get on my mailing list for this and other articles, email me at Brendan@leabrook.co.uk

Author

Brendan McNamara worked on Fusion Theory and Computations with AEA Technology, Culham (1961-71) and at the Lawrence Livermore National Labs in California (1971-84). He also directed a series of Plasma Physics Colleges at ICTP, Trieste, 1974-84. He was Exec. V.P. of a Supercomputer Center in Princeton (1985-88) and now operates Leabrook Computing as a Consultancy.

References & Reading List

Appenzeller, Tim. 'The End of Cheap Oil' National Geographic June 2004. Well illustrated and balanced account of world problems.
ASPO www.peakoil.net. Colin Cambell leads this group and edits their newsletters available here. ASPO Conference papers can be downloaded.
Bentley, Roger. 'Global Oil and Gas Depletion; an overview' Energy Policy 30 (2002) 189-205. Reviews the competing modelling methodologies.
Darley, Julian. 'High Noon for Natural Gas' Chelsea Green, 2004. Brilliant report of the looming problems with gas.
Deffeyes , Kenneth .S.. Hubbert's Peak. Princeton Press, 2001. Accessible geologist's account of oil exploration and exploitation and the coming decline. Still the best.
Goodstein , David.. 'Out of Gas' Norton & Co., New York, 2004. Popular Science basis of oil decline and global warming.
Heinberg , Richard. 'The Party's Over' Clairview 2004. Science writer's view of ASPO position. Gives credence to absurd Cold Fusion notions.
Harper , Francis, B.P. 'Oil Reserves Growth Potential', ASPO Conference, Berlin, 2004. Example of how mixed data produces wondrous interpretations.
Howe , John. 'The End of Fossil Energy' McIntire Publishing, 2003. Dark but excellent discussion of sustainability.
McNamara , B.. 'The Coming Energy Winter and the Future of Fusion'. EPS Plasma Physics Conf., July 2004. Currently available from www.world-nuclear.org or from brendan@leabrook.co.uk.
Odell , Peter. 'Why Carbon Fuels will dominate the 21st Century's Global Energy Economy' Multiscience, 2004. A prime source for supply and demand fantasies.
Roberts , Paul. 'The End of Oil' Clays Ltd., 2004. Journalist's view of USGS predictions. Fusion discounted.
Simmons, Matthew. 'Twilight in the Desert: The fading of Saudi Oil', 2004. One of many presentations at www.simmonsco-intl.com
Simpson, Homer. 'If you don't like it at work, don't resign. Just go in every day and do a crap job.'
Smith, Michael. Inst. Energy Conf., London 2004. www.energyfiles.com
Stiglitz ,Joseph.. 'Globalisation and its Discontents'. Penguin Books 2002. Ex-World Bank economist and Nobel Laureate expose of many failures.
P.S. Szwed and J.R. van Dorp, "A BAYESIAN MODEL FOR RARE EVENT RISK SSESSMENT USING EXPERT JUDGMENT ABOUT PAIRED SCENARIO COMPARISONS" – web search.