## ANNOTATIONS/AMENDMENTS

January 2005

Dear Reader,

Some readers felt, quite rightly, that the dialogue in the White House scene justifying the invasion of Burkino Faso (pages 16-23) was utterly ludicrous. Accordingly, I have collated references to show just how closely that ludicrous dialogue reflects the sad truth of the current American (and British) ruling regime(s). The profane language used by the American Presidents in other scenes was not a patch on the old Nixon tapes.

**Page 19 top: "Unfortunately the Good Lord didn't see fit to put uranium only where there are democratic regimes friendly to the United States."**
*"Defending Liberty in a Global Economy", The Collateral Damage Conference, Cato Institute June 23, 1998:*
"The good Lord didn't see fit to put oil and gas only where there are democratically elected regimes friendly to the United States. Occasionally we have to operate in places where, all things considered, one would not normally choose to go. But we go where the business is." - Richard B. Cheney

**Page 20 top: "forty five minute alert":**
*Financial Times, New York Times, Washington Post, 25 September 2002*:
"British Prime Minister Tony Blair released a 50-page report claiming that Iraq could launch chemical warheads within 45 minutes, and that the country was one to five years away from having nuclear capabilities. Iraq emphatically denounced the report as false and again insisted that a new batch of UN inspectors would be given free access to all sites."

*"Do not use 45-minute claim, CIA told No 10", The Guardian, Thursday July 31, 2003:*
"The CIA objected to claims in the British government's September dossier on Iraq's banned weapons programme, the issue at the heart of the Kelly affair, it was revealed yesterday. It appears that among the CIA's objections was the much-trumpeted claim that Iraqi forces could deploy chemical and biological weapons within 45 minutes of an order to do so. That claim was strongly challenged by David Kelly, the government's senior scientific adviser, and will be one of the issues at the heart of the Hutton judicial inquiry into the circumstances leading up to his death. The inquiry opens in London tomorrow. The 45 minutes claim was questioned by Dr Kelly, Whitehall's top adviser on chemical and biological weapons, both in conversations with BBC journalists and in evidence he gave to the foreign affairs committee on July 15, two days before he apparently killed himself. Dr Kelly, a former UN inspector in Iraq, told the committee that it 'would be very difficult to see how Iraq could deploy in 45 minutes'." - Richard Norton-Taylor and David Leigh

**Page 20 mid: "mushroom cloud":**
*Cincinnati OH, 10 July 2002:*
"…we cannot wait for the final proof, the smoking gun that could come in the form of a mushroom cloud…" - George W. Bush, in the buildup to the Iraqi invasion

**Page 20 mid: "fifty thousand troops":**
*"Pentagon Contradicts General on Iraq Occupation Force's Size", New York Times, February 28, 2003:*
"Mr. (Paul) Wolfowitz, the deputy defense secretary, opened a two-front war of words on Capitol Hill, calling the recent estimate by Gen. Eric K. Shinseki of the Army that several hundred thousand troops would be needed in postwar Iraq, 'wildly off the mark'. Pentagon officials have put the figure closer to 100,000 troops. At a Pentagon news conference with President Hamid Karzai of

Afghanistan, Mr. Rumsfeld echoed his deputy's comments. Neither Mr. Rumsfeld nor Mr. Wolfowitz mentioned General Shinseki, the Army chief of staff, by name. But both men were clearly irritated at the general's suggestion that a postwar Iraq might require many more forces than the 100,000 American troops and the tens of thousands of allied forces that are also expected to join a reconstruction effort…" - Eric Schmitt

*"U.S. Troop Level In Iraq To Grow: Will Be Extended for Elections", Washington Post, Thursday, December 2, 2004:*
"The Pentagon said yesterday that it will boost the number of U.S. troops in Iraq to about 150,000, the highest level since the U.S. occupation began 19 months ago… Some observers said the latest announcement indicates that the Pentagon is recognizing just how long the effort in Iraq may take. 'This announcement makes it clear that commanders in Iraq need more troops and that this will be a long and very expensive process for the United States,' said Sen. Jack Reed (D-R.I.), a member of the Armed Services Committee who recently returned from a visit to Iraq." - Thomas E. Ricks

*"War on the Cheap", New York Times Editorial, December 20, 2004:*
"From the earliest planning stages until now, the war in Iraq has been a tragic exercise in official incompetence. The original rationale for the war was wrong. The intelligence was wrong. The estimates of required troop strength were wrong. The war hawks' guesses about the response of the Iraqi people were wrong. The cost estimates were wrong, and on and on. Nevertheless the troops have fought valiantly, and the price paid by many has been horrific. They all deserve better than the bad faith and shoddy treatment they are receiving from the highest officials of their government…"

**Page 20 mid: "ensure America's energy security":**
*From www.krysstal.com/democracy_whyusa_iraq.html(2004):*
"Dick Cheney used to head Halliburton (the world's biggest oil-services company worth $18,200 million). From 1992 to 2004, Halliburton contributed $1,600 million to politicians. It was a co-sponsor to a measure to open the Arctic National Wildlife Refuge to oil drilling and voted against the Clean Water Act which required industries to release their toxic emission records. Since 1998, Halliburton has completed $24 million worth of repairs to Iraqi oil pipelines. Dick Cheney, [who was put in charge of the National Energy Policy Development Group], has stated that 'energy security should be the priority of USA foreign policy' *(National Energy Policy report 01-NEPD4 , May 2, 2001.)*"

*"Is energy independence an impossible goal?", the New Yorker, October 11, 2004:*
"In 1999, when Cheney was still at Halliburton, he gave a speech at London's Institute of Petroleum in which he pointed out that by 2010 the world would probably need another fifty million barrels of oil a day. 'So where is the oil going to come from?' Cheney asked. 'While many regions of the world offer great oil opportunities, the Middle East, with two-thirds of the world's oil and the lowest cost, is still where the prize ultimately lies.' - John Cassidy

**Page 20 mid: "It all reminds me of September 11":**
*Baltimore Sun, November 9, 1998:*
"1975 Frank Church, then chairman of the Senate Intelligence Committee, concluded that the CIA, in a shadowy alliance with U.S. corporations, carried out 'massive covert operations within a democratic state [Chile], with the ultimate effect of overthrowing [the] duly elected government'." - Maurice Zeitlin

*"U. S. Documents Confirm Destabilisation of Allende", InterPress Service, 11 Sep 98:*
"Nixon informed CIA Director Richard Helms that an Allende regime in Chile would not be acceptable to the United States and instructed the CIA to play a direct role in organizing a military coup d'etat in Chile to prevent Allende's accession to the Presidency." - Jim Lobe

**Page 21 top: "what's the point of having the strongest military if we don't use it?"**
*From http://archives.cnn.com/2001/US/01/10/albright.farewell/#4:*
"In 1993, Madeleine Albright, then U.S. ambassador to the United Nations said to Colin Powell, then Chairman of the Joint Chiefs of Staff (regarding sending troops to Bosnia), 'What's the point in having this superb military you are always talking about if we can't use it?'

In his 1995 book, Powell said of the incident: 'I thought I would have an aneurysm. American GIs were not toy soldiers to be moved around on some sort of global game board.'"

Other memorable quotes from Ms. Albright:

*Television interview, "60 Minutes", May 12, 1996:*
*Lesley Stahl, speaking of US sanctions against Iraq:* "We have heard that a half million children have died. I mean, that's more children than died in Hiroshima. And...and you know, is the price worth it?"
*Madeleine Albright:* "I think this is a very hard choice, but the price...we think the price is worth it."

*Washington Post, April 23, 1997, p.4:*
Asked if it is not hypocritical to punish Burma for human rights violations while refraining from sanctions on China for similar, Albright replied, "We have consistent principles and flexible tactics".

**Page 21 mid: "Our preemptive policy justifies action on the basis of assertions which we don't know that we don't know."**
*Department of Defense News Briefing, February 12, 2002:*
"…as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns - the ones we don't know we don't know…" – Donald Rumsfeld, US Secretary of Defense

**Page 22 top: "Repeat a lie often enough and people will eventually swallow it…The fact that I own so many different news vehicles gives people the impression that they are receiving information from lots of independent sources."**
*Readers' letters, The Nation, 6 May 1996:*
"…two of the principles established (in 1940) by the Nazi propagandist Dr Joseph Goebbels himself: firstly, that if you repeat a simple lie often enough, it will eventually be believed; secondly, that you must never be seen to initiate the lie in your own journals, but always plant it somewhere else. Goebbels would start his lies in, for example, the ostensibly neutral wartime *Svenska Dagbladet*, and then 'quote' it as coming from that source…" - David Irving, author of "*Goebbels: Mastermind of the Third Reich*"

**Page 22 mid: "Counting civilian deaths brings us bad publicity. We don't do it."**
*The Guardian , 29 October 2004:*
"About 100,000 Iraqi civilians - half of them women and children - have died in Iraq since the (American) invasion, mostly as a result of

air strikes by coalition forces, according to the first reliable study of the death toll from Iraqi and US public health experts. The study, which was carried out in 33 randomly-chosen neighbourhoods of Iraq representative of the entire population, shows that violence is now the leading cause of death in Iraq. Before the invasion, most people died of heart attacks, stroke and chronic illness. The risk of a violent death is now 58 times higher than it was before the invasion. Last night the *Lancet* medical journal fast-tracked the survey to publication on its website after rapid, but extensive peer review and editing because, said Lancet editor Richard Horton, "of its importance to the evolving security situation in Iraq". But the findings raised important questions also for the governments of the United Sates and Britain who, said Dr Horton in a commentary, 'must have considered the likely effects of their actions for civilians.'" - Sarah Boseley, health editor

**Page 23 mid: "People are either with us or against us in this crusade…"**
*Press conference September 16, 2001:*
*(www.whitehouse.gov/news/releases/2001/09/20010916-2.html)*
"…this crusade, this war on terrorism…" - George W. Bush

*6 Nov 2001:*"You're either with us or against us in the fight against terror." – George W. Bush

*24 June 2002:*"I've said in the past that nations are either with us or against us in the war on terror." - Bush yet again

*"You Scare Us - Bush is Giving Latin America the Willies", Los Angeles Times, Sunday, September 26, 2004*:
"What is alarming about the Bush administration is its formal denunciation of the basic rules of international intercourse. With us or against us, President Bush declares starkly and simplistically. The U.S. acts according to its own interests, 'not those of an illusory

international community,' asserts national security advisor Condoleezza Rice." - Carlos Fuentes

**Amended ending for "Operation spoil and seize" page 155:**

*Peter Dogowitz (CIA):* Yeah, the six guys on our ship who died. Also five crew on the NEATO vessel died.

*President Lance Boyle:* Hell, those goddamn commies deserved what they got. Serves them right for carrying one megaton of explosive on board. Jesus! One megaton! For all we know they planned to use it against us on Earth. A goddamn nukular bomb ship posing as a mining ship.

*Peter Dogowitz (CIA):* Quite possibly, Sir. I guess they had it coming to them.

*Lance Boyle:* Damn straight they did, the commie bastards.

*Anthony Manetti (NASA):* One more thing, Mr President. Sinojapanese mission control intercepted and eventually decoded transmissions from the *Geronimo* talking about our limpet mine. The NEATOs are outraged and accuse us of sabotage. They demand 20 billion in compensation.

*Lance Boyle:* Ignore them.Tell them to piss off. Peter, you know how to apply our doctrine of plausible deniability. Use our good friends in the Matlock press to portray them as whiny complainers, unable to accept responsibility for their own incompetence. Don't worry about it. It will all blow over in time.

*Anthony Manetti (NASA):* But Sir, they cite those transmissions as factual evidence of American skulduggery. At the very least they demand an official apology.

*Lance Boyle:* **I don't care what the facts are. I will never apologise for the United States of America.**

*On July 3, 1988 the U.S. Navy warship Vincennes shot down an Iranian commercial airliner. All 290 civilian people in the aircraft were killed. The plane was on a routine flight in a commercial corridor in Iranian airspace.*

"I will never apologize for the United States of America - I don't care what the facts are." - President George Bush Sr, commented in response to that incident.

**Page 179 bottom: "The French have no phrase for 'Laissez-Faire'"**
*Washington Post, Wednesday, July 10, 2002; Page C03:*
"…liberal politician Shirley Williams recounted to an audience in Brighton that 'my good friend Tony Blair' told her the following anecdote: 'Blair, Bush and [French President] Jacques Chirac were discussing economics and, in particular, the decline of the French economy. 'The problem with the French,' Bush confided to Blair, 'is that they don't have a word for entrepreneur.'"
– Lloyd Grove, Staff Writer

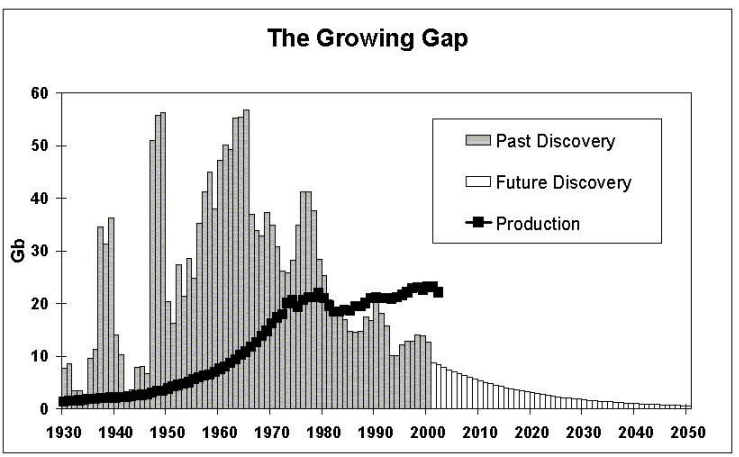
*Webster's New Collegiate Dictionary* says the noun, "Entrepreneur" originates from the French word entreprendre, which means "to undertake".

**Page 179 bottom: "…Ronald Bumstead, the future US Foreign Secretary, called us 'washed out old Europe'."**
*BBC News, Thursday, 23 January 2003 (http://news.bbc.co.uk/1/hi/world/europe/2687403.stm):*
"French and German leaders have reacted angrily to comments by the US Defence Secretary Donald Rumsfeld describing the two countries as 'problems' in the crisis over Iraq. French Finance Minister Francis Mer said he was 'profoundly vexed' by Mr Rumsfeld's remarks - which branded France and Germany 'old Europe' - while a former employment minister described the US as arrogant. German Foreign Minister Joschka Fischer said that the word 'problem' was inappropriate."

## ESSAY: "Better paradigms for our energy futures: From fossil fuels to *phytofuels* to *photofuels*"

Back in the 1950s, a geophysicist named M. King Hubbert predicted that *American* peak oil production would occur in the early 1970s. He was proven absolutely correct. Since then, there has been a relentless decline in flow from the US oilwells - which now represents just 3% of world reserves. Numerous scientists applying Dr. Hubbert's analytical techniques have since determined that *World* peak petroleum production, the eponymous *"Hubbert Peak"*, will be reached before 2010 and indeed may well have been passed by now.

Given the mature state of the geological sciences, it is virtually certain that all reserves of readily extractable oil have already been identified – no more exist. It has been estimated that affordable petroleum will be depleted within 40 years[1].




*Graph by: Dr. Colin J. Campbell, Oil Depletion Analysis Centre, London*

Thus we can expect an inevitable reduction of oil output from now on, even as there is a worldwide burgeoning demand for petroleum, particularly from the rapidly developing countries such as China and India. At the same time, America, representing less than 5% of the World's population, continues to consume 25% of all petroleum and remains the largest producer of carbon emissions, while officially casting doubt on the existence and/or importance of global warming. Political measures by the American automobile and oil companies to heavily artificially subsidise gasoline for their consumers, coupled with perverse government incentives to popularise gas guzzling vehicles such as SUVs (sports utility vehicles) serve to exacerbate a looming global crisis[2], while America defiantly cocks a snook at the rest of the world.

Wars have been and are being fought over petroleum. The Japanese assert that Pearl Harbour was provoked by the American threat to cut off their oil[3].

What was the real reason for America's invasion of Iraq? It had nothing to do with Al Queda or terrorism, nothing to do with weapons of mass destruction, nothing to do with liberating people from a brutal dictator and nothing to do with creating a better, safer life for the average Iraqi[4]. (As of October 2004, the average Iraqi faced a 58 fold higher risk of violent death under American administration compared to when Saddam Hussein was in power[5]).

There is no doubt the US invasion of Iraq was primarily related to America's sense of entitlement for "energy security" and continued access to cheap oil; their belief in their God-given right to the profligate consumption of petroleum irrespective of future global consequences[2,6]. Of course, the Republican neoconservatives will never admit to this – to do so will prove them to be the duplicitous morally bankrupt characters they are.

The only connection between September 11, 2001 (in which fifteen of the nineteen airline hijackers were Saudi Arabian Nationals[7]) and the US invasion of Iraq was the realisation by America that their continued access to cheap Saudi Arabian oil was

far more precarious than they had hitherto suspected. The Saudi Royal family are holding on to power by a thread and are deeply resented by the Saudi populace – they are perceived by many common Saudis as a corrupt self serving regime propped up by American self interest[8,9].

Loss of access to cheap oil from Saudi Arabia, the country with the largest reserves in the world, was and is unacceptable to America. So how best to hedge their bets? Secure a supply from the country with the second largest reserves – Iraq.

Senator John Kerry, the Democratic presidential candidate in the 2004 US election campaign, highlighted energy independence and the pursuit of alternative (non-fossil fuel) energy sources as crucial issues, which was tantamount to admitting that the Iraqi invasion was all about oil.

At the Democratic Convention in July, Kerry said in his speech: *"I want an America that relies on its own ingenuity and innovation —not on the Saudi royal family…and our energy plan for a stronger America will invest in new technologies and alternative fuels and the cars of the future—so that no young American in uniform will ever be held hostage to our dependence on oil from the Middle East."* [2].

He failed in his presidential bid, suggesting to me at least, that the average American couldn't care less about such matters.

Bush's agenda however involves the use of more fossil fuels, including a controversial proposal to begin drilling for oil in the Arctic National Wildlife Refuge[2].

Australia is equally culpable and delinquent in supporting and emulating America's disingenuous policies. Our two nations alone remain defiant among developed nations in their refusal to sign the Kyoto protocol, now that Russia has become a signatory[10].

Surely globalisation of trade and profit opportunities also require that responsibilities for a sustainable future and for environmental conservation are shared globally. Surely it is reasonable to expect that the nations which are the highest per capita consumers of fossil

fuels (and the worst per capita polluters) ought to bear the greatest responsibilities.

What scenarios may we anticipate for our energy futures? Many paradigms have been advocated.

What is clearly unacceptable however, is adoption of the American strategy of denial of scientific evidence, perverse incentives to encourage ongoing profligate oil consumption and unconscionable pollution, and illegitimate invasion of other countries to ensure one's own "energy security". Emulation of such despicable behaviour by other major powers will inevitably lead to wars over future energy resources[11].

There must be a better way.

Here is one suggestion: we should invest in scum. Confused? Read on and all will be revealed.

## Advantages and disadvantages of the various energy sources

The drawbacks of the **fossil fuels** are well known: carbon emissions, the greenhouse effect and global warming, pollution by impurities or additives (sulphur dioxide, lead compounds), acid rain and especially the fact that they are a non renewable resource.

**Nuclear fission** looked very promising in the past (before the Three Mile Island and Chernobyl disasters and concerns about terrorism) and provides a large proportion of energy for some countries such as France and Korea [12]. In the short term, it appeared to be non polluting. Unfortunately, radioactive plutonium is a rather nasty substance. A single speck of plutonium dust has the potential to cause lung cancer in an individual who inhales it[13,14]. The effects of radioactive caesium and iodine entering the food chain are well known.The use of so-called "depleted" uranium warheads in Iraq has been associated with numerous adverse health effects in children and others[15,16], despite denials by the US government[17].

Clearly however, an option such as nuclear fission which allows a State with few alternative sources to be less dependent on oil and

which has a "petroleum sparing" effect will continue to remain attractive, despite the thorny unresolved issues of disposal of nuclear waste and decommissioning of old nuclear plants (which may end up being encased in concrete and cordoned off for decades at great expense). Furthermore there is potential for the acquisition of materials by rogue states or terrorists for bomb building or just making "dirty" conventional bombs to spread radioactive dust.

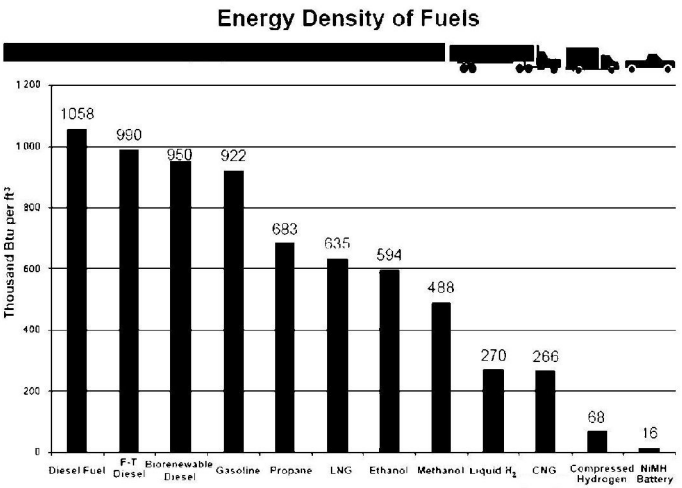
**Renewable sources** of energy such as photovoltaic, wind, geothermal, hydroelectric or tidal energy are tremendously appealing, but are applicable only to specific geographic areas and often with wide fluctuations in availability.

**Petroleum** products continue to be an indispensible source of energy for the transport industry and there are good reasons for this. Apart from the economic reasons, **oil based fuels are a near ideal chemical energy source** for the following reasons:

1. **High energy density:** Biochemically, fats and oils are the most concentrated sources of energy per unit weight or volume. For instance, the calorific value of fats and oils is 9kcal/g as compared with 4kcal/g for either carbohydrates or proteins and 7kcal/g for ethanol[18]. With regard to transport/industrial fuels, energy density (by energy per unit volume in btu/cubic foot) is highest for diesel at 1058, similar for biodiesel and gasoline at 950 and 922 respectively, lower for propane and liquid natural gas at 683 and 635 respectively, even lower for ethanol and methanol at 594 and 488 respectively, much lower for liquid hydrogen at 270 and pathetically poor for compressed hydrogen at 68[19].

   Liquid hydrogen may well be the most energy dense in terms of energy per unit weight (and thus suitable for rocket propulsion), however to enable the same performance and range for more mundane vehicles such as cars or trucks, fuel tanks almost four times larger than normal diesel tanks will be required. This will of course represent loss of revenue cargo

space and the larger pressurised tanks will also represent additional non cargo weight to be carried about.




*Graph by: Dr James J Eberhardt, "Fuels for the future for cars and trucks", US Department of energy 2002*

2. **Advantages of the liquid medium:** Gaseous fuels e.g. Compressed natural gas or methane have low energy densities (per unit volume) and are difficult and bulky to transport and contain, requiring pressurised containers. Solid fuels cannot be readily atomised to produce an air-fuel mixture to power internal combustion or jet engines. Liquid fuels (ie. Fuels which are liquid at normal temperatures and pressures) overcome both disadvantages, with the added benefit that they can take on the shape of any container (unlike solid fuels) such as the wing tanks of aircraft, resulting in space optimization. The ideal fuel will remain liquid at extremes of temperature, even the sub zero Antarctic or the scorching Sahara.

3. **Transportability and storage:** For electricity to be distributed, power lines, pylons and cables need to be set up and transformers/substations built. The electricity will be available only at fixed outlets and needs to be consumed directly. Petroleum products can be transported to any site unrestricted by fixed lines of delivery and can be stored for future utilization at any date.

4. **Aviation:** There is no energy source at present which is superior to or can effectively substitute for petroleum products for aviation. Nuclear, hydroelectric, wind and geothermal power may generate electricity, but how may this electricity be stored on an aircraft and produce power to match that of a jet engine? Expensive hydrogen powered space rockets and experimental planes exist but we have no precedent for a practical hydrogen powered commercial transport plane. Furthermore, hydrogen combustion planes will produce water vapour which, although probably innocuous at ground level represents a potent greenhouse gas when expelled into the upper atmosphere and will exacerbate global warming[20]. Without petroleum, the entire air transport industry will grind to a halt. One may conceive of alcohol or LPG powered planes, but again, due to the lower energy density of these fuels or bulky storage containers, the performance and range of such aircraft will be inferior.

**Interim measures**

What measures should we take now to minimise the shock of the upcoming oil crisis? Conservation will go a long way to delay the inevitable oil shortages. Cogeneration (burning waste to produce heat and electricity), better building construction (insulation, reflective glass etc.), more efficient engines, hybrid engines, use of alternative energy sources to "spare" petroleum and so forth will help.

It has been estimated that "*if the United States became as energy-efficient as Germany, it would consume 50 percent less energy, a reduction equivalent to more than twice the level of U.S. Imports of Saudi oil.*[9]"

When the present oil fields run dry, there are other means of obtaining oil (from "non conventional sources"): from oil shale or oil sands, or by injecting detergents into previously tapped oil wells, or by synthesizing oil from coal or natural gas. These methods exist now but are little utilised being generally not cost competitive with good old crude.

But here is the other problem: in doing our utmost to extricate every last bit of energy from all the corpses of organisms accumulated underground over the past billion years, we will also ensure that every last bit of the carbon locked up in these fossils will have been released into the atmosphere.

No reasonable person these days can deny the truth of global warming or that it is the result of human activities[21,22].

There is merit to the idea of trading in carbon credits[23], now an approaching reality since the Kyoto Protocol was ratified. Pumping carbon dioxide underground into "carbon sinks" has been advocated[24]. To me, this sounds like sweeping a problem under the carpet and is a diversion, a red herring – not a solution. There is no guarantee that the carbon dioxide will not leak out into the atmosphere eventually.

The above are all just temporizing measures however. After that, notwithstanding any breakthrough, air travel will all but disappear. Some might say the return to an agrarian lifestyle is the way to go[25]. This is unlikely to be acceptable to the majority of people used to a high standard of living. Furthermore, in a world of 6 billion people (possibly 9 billion by mid century), it will be impossible to revert to low productivity agricultural economies without mass starvation.

**The nuclear fusion / hydrogen scenario**

Let me now outline the future energy scenario that many Physicists and some politicians will have us believe in – it is a big money scheme, and we're talking trillions of dollars:

A few (?ten ?fifty) years from now there is a major breakthrough in fusion research (research which has already cost multiple billions to date) and electricity becomes laughably plentiful and essentially inexhaustible. So powering our cities and many industries is no longer a problem and it is all pollution free.

What of transportation? Over land, the electric vehicle will come into its own, whether by road or rail. Sea transport is a little trickier as it is unlikely that fusion generators (?Tokomaks) may be reduced to a size that even a super tanker could contain in the near future, and even if they could, it may not be cost effective. Independent fusion units would certainly be out of the question for small craft. The need for a new aviation fuel will still remain and will not be solved by abundant electricity.

The answer to these issues, we are told, is hydrogen, derived from the electrolysis of water. And hydrogen is so wonderful because when you burn it (or utilise it in a fuel cell), all you get is nothing more than water again – no pollution. Thus we will have hydrogen powered ships and jet aircraft. The only problem is, this will entail the complete redesign of current fuel storage, transportation and distribution facilities around the world, not to mention new engines and tanks on all these craft. Can liquid hydrogen be transported across thousands of miles by pipeline as oil is currently being done? Liquid hydrogen would be immensely more difficult to store and handle than current petroleum based fuels. Bulky pressurized and heavily insulated hermetic tanks will be necessary. Precautions must be taken in handling this intensely cold commodity, cryogenic technology must be introduced.

Another major problem will be the inevitable "boil off" of liquid hydrogen if stored for any length of time, which will represent a

large waste and be dangerous if occurring in an enclosed environment (hydrogen is the smallest atom and thus the easiest to leak out of containers). The potential for accidents will be ever present, hydrogen being more volatile than many petroleum products (for instance – throw a burning match into a pool of cold kerosene or diesel and what do you get? An extinguished match.) The image of the burning Hindenburg may not be a fair one to conjure up but it is an inevitable one.

What if I were in the middle of a desert at night, or in a boat in the middle of the sea at night, and needed an energy source to run my generator or tractor or boat engine? Diesel or petrol are very convenient for this and it is difficult to conceive how hydrogen could supplant these fuels in small scale geographically isolated situations. Direct solar or wind generated electricity cannot provide sufficient power for many tasks.

In any case, the Holy Grail of fusion energy remains an unattainable illusion for now and the foreseeable future. As the joke goes, fusion energy is just forty years away from us – and always will be[26].

**Better paradigms**

There are more practical energy sources and technologies which are available right here and now. These sources are sustainable and renewable and do not result in a net increase of carbon dioxide in the atmosphere. Collectively we term this "biomass energy".

What do I mean by "do not result in a net increase of carbon dioxide in the atmosphere"? Surely when one burns a piece of wood, carbon dioxide is released? The answer is simple: so long as a new tree is planted for every equivalent mass of wood burnt, there is no net increase in atmospheric carbon dioxide, as the growing tree will lock atmospheric carbon into its mass again. This is the attraction of all biomass energy provided we replenish everything we burn.

Is biomass energy just a fancy term for cow dung and wood and

other organic matter which humans have used throughout history anyway? If so, what is the big deal?

New approaches to biomass energy were introduced last century. Small scale methane-from-sewage projects are now widespread throughout China and India. One of the most ambitious schemes is the Brazilian National Alcohol Programme where sugar cane is used to produce ethanol which, alone or mixed with gasoline has gone a long way to reduce their dependency on petroleum. Ethanol in Brazil now sells for about 60-70% of the cost of petrol in the free market[27].

Other strategies to convert wood and plant waste to usable hydrocarbon fuels, whether aqeous (fermentation, chemical reduction) or thermochemical (pyrolysis, gasification, hydrogasification) have not proved to be practical or viable on a large scale.

Nevertheless, I believe modern methods can allow biomass energy to substitute for petroleum based fuels, including aviation fuels. This has already been done in a limited manner.

Towards the end of World War Two when the Japanese ran out of oil, they resorted to pine resin to power their fighter planes for some missions. It worked to a degree although the engines tended to gum up[28]. Few would be surprised with the suggestion that good old turpentine can be used as a fuel. Rudolf Diesel himself wrote in 1911 that “the diesel engine can be fed with vegetable oil”, a fact proven time and again at various times and places. Tractors were run on sunflower oil in South Africa many decades ago. During World War Two the Chinese developed an industrial process for cracking vegetable oils and turning them into motor fuels which did not clog engines[29].

Nowadays biodiesel is no longer considered experimental and is available at many roadside bowsers in Europe for use in ordinary diesel vehicles with minimal engine modification (the Germans are particulary far sighted in this respect). Techniques have now advanced to the stage that private individuals can utilise kitchen-

chemistry kits to convert their waste cooking oil to biodiesel to power their family cars. The exhaust apparently smells faintly of – french fries![30]

Modern diesel powered piston aviation engines may well replace avgas (leaded petrol) powered piston engines for light aircraft in the next few years for many practical reasons. (The Morane Renault company has been one pioneer in this respect).

Diesel fuel is physically and chemically very similar to kerosene which is, of course, none other than jet fuel.

Let us now summarise the characteristics of the ideal fuel. It should have all the advantages of petroleum based oils i.e. Have a high energy density, be a liquid over a wide range of ambient temperatures and it (or its derivatives) should be a viable aviation fuel. It should have none of the disadvantages of fossil fuels i.e. It should be renewable, should not add to the net carbon dioxide load in the atmosphere and it should be minimally polluting. It should have none of the handling disadvantages of liquid hydrogen – which it will not if it has the physical characteristics of petroleum based oils.

It should also have a minimal environmental impact in the event of a spill or leak and should be biodegradable. Additionally, it should be non-toxic. Some hydrocarbon based fuels are quite poisonous e.g. Methanol can induce metabolic acidosis and blindness and benzene is carcinogenic. Even diesel emissions contain carcinogenic polycyclic aromatic hydrocarbons (far less in biodiesel emissions).A major bonus would be if this fuel could be used in existing engines with no or minimal modification.

Now we come to the speculative, perhaps controversial part. I believe it is possible for us to create the ideal (or near ideal) fuel with existing technology.

Virtually all the chemical energy we use today is ultimately derived, directly or indirectly, from the photosynthetic process, and this is where I believe our efforts must be concentrated.

The question is, what is the most direct and most cost effective

way of converting sunlight into liquid hydrocarbons (preferably oil, although alcohol is also useful) rapidly and in volume?

**Phytofuels**

In the first instance we should strive to produce a plant derived oil – what I term a ***"phytofuel".*** The biggest obstacles to its development are economic and political. It will need to be price competitive with petroleum based oils and be able to meet current and future demands i.e. Will have to be produced cheaply on a large scale.

Growing sugar cane then converting it to alcohol (which has a lower energy density than oil) is a two stage process. Furthermore there is opportunity cost in that cane fields can be used for growing other crops, and sugar itself is a worthwhile commodity whose value may exceed that of the alcohol produced, depending on market circumstances. Similar issues hold for the vegetable oils, in that there is opportunity cost in the land utilisation and the oils themselves are useful commodities in non-fuel applications. The same applies to pine oils. Additionally, much of the solar energy, water and nutrients consumed during the growth of these crops goes into the formation of roots, stems or other plant parts which we are not primarily be interested in. This brings us to the **characteristics of the ideal fuel crop**.

The ideal fuel crop should:

1. Grow rapidly and be harvested easily.
2. Utilise land (or even lake or marine areas) not otherwise useful for other purposes.
3. Efficiently convert sunlight, water, $CO_2$ and nutrients to the end product i.e. Oil, with minimal diversion of energy into the formation of other plant parts. In the extreme situation, such a plant would consist of little more than chloroplasts and oil producing organelles surrounded by a cell membrane – namely, an algal species.

4. Not require significant extraneous application of fertilisers. For example, perhaps the nitrogen fixation ability of legumes can be spliced into the genome of the oil crop.
5. If fresh water is in short supply, be able to use sea or brackish or artesian water.
6. Should it inadvertently escape the confines of the "fuel farms" it should not proliferate rampantly and pose an ecological hazard. Perhaps a self destruct sequence could be built into its genes or it could be engineered to require an essential nutrient not normally found in the greater environment.

One inescapable criterion, however, will be that such a crop will require lots of sunshine. Perhaps areas like outback Australia or Arizona could prove to be just the place for such "fuel farms".

Of course, such a plant does not exist. Not now, at any rate. Consider this however: simple selective plant breeding has enabled Mankind to exponentially increase the food yield of cereal crops, transforming grain poor wild grasses into the highly productive staples of rice, wheat and maize we know today[31].

We now have our disposal a far more powerful and efficient tool than simple selective breeding: biotechnology. I believe biotechnology will enable us to create plants with far greater oil productivity than the current traditional bio-oil sources such as canola, soyabean or oil palm, dramatically increasing the economic competitiveness of such oils. But innovation and investment are required. Creation of economically viable "*phytofuels*" will involve genetic engineering, the controversies surrounding which need to be discussed separately. Given the current state of biotechnology, it is entirely feasible to introduce an oil producing gene into a rapidly growing algal species to produce such a plant. Some algae already have a very high lipid content e.g. *Botryococcus braunii* has been found to synthesize large amounts of hydrocarbons with oil contents of up to 86% of dry weight[32] . Some microalgae have a doubling time of less than a day.
Hence my initial suggestion – that we should invest in scum.

Other possibilities include bioengineering seaweed or kelp for the same purpose. In all probability there will be no single ideal fuel crop but several different sorts, depending on the local environments where they will be grown, producing different sorts of oils for different uses.

Some preliminary research has already been done on the above, dating back several decades. However, no breakthrough has occurred, largely, I believe, due to lack of funds and lack of interest especially because of current artificially cheap petroleum prices. Barring another petroleum crisis or John Howard being unexpectedly afflicted by an attack of decency, there is unlikely to be adequate Government support for such a project.

Biotechnology may also be the key to the production of new renewable polymers and plastics, which, after all, are presently derived from petroleum. But that is a whole other story.

**Photofuels**

Will the development of bioengineered *phytofuels* solve all our energy problems? Almost certainly not. At the very least however, my hope is that *phytofuels* will replace fossil fuels in the transport industry, and that vehicles with hybrid[33] *phytofuel*-electric engines will become the environmentally friendly standard.

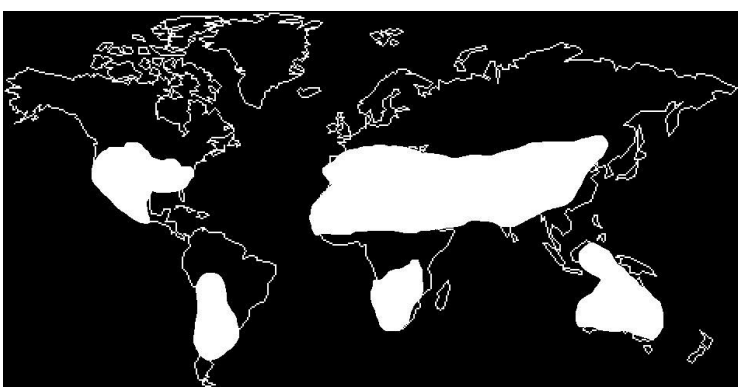
It is likely that nuclear fission, hydroelectricity and increasingly, wind power, will be important sources for future electricity generation.

We do not know at this time the maximum volumes of oil which can feasibly be produced by bioengineered plants. However there may be another strategy which could far exceed the solar energy gathering efficiency of even the most wildly productive bioengineered oil plant and utilise far less water.

The rate at which solar energy is delivered to the entire Earth's surface, despite cloud cover, atmospheric attenuation (reflection, scattering, absorption), cosine effect (obliquity of rays at locations

above or below the equator), rotation of the Earth (day and night phases) and other factors, averages a total of 1.2 x $10^{17}$ watts, or *20 thousand times* the total rate of human consumption[34]. It is clear that there is huge potential to vastly increase our energy collection from the sun. By my own back-of-the-envelope calculation, a 100% efficient solar energy collecting facility will need to be about 10% the area of the Nullabor Plain to meet *all* the world's energy needs – a tiny dot on the map of the world[35]. If we were able to develop a 33% efficient solar process, a facility comprising 30% the area of the Nullabor Plain (75,000 square kilometres) may be required (much less if we can curb our present rampant profligate habits).

Certainly that represents a huge land area, however we should compare that figure with the estimation by an Utrecht University team, that for *wind* power to the meet the global *electricity* (not total energy) demands of 2001, a land area of 2.4 *million* square kilometres (about the size of Saudi Arabia) will be required, which one science journalist considered an *upbeat* assessment![36].



*Map of areas of high solar insolation*

Nevertheless, 75,000 square kilometres *is* a massive land area and a single such solar gathering facility will represent a monumental engineering feat far exceeding that of the Great Wall of China. A much more practical and likely scenario is that several hundred such facilities should be built around the world in areas of high insolation to collectively add up to such an area. What sort of solar energy collecting facilities are we talking about?

Let us revisit a question previously posed: *what is the most direct and most cost effective way of converting sunlight into liquid hydrocarbons rapidly and in volume?*

I believe that, far more efficient than bioengineered "*phytofuels*", the direct conversion of light energy to hydrocarbons will ultimately be the way to go – in other words, **artificial photosynthesis –** to enable the production of what I term a **"*photofuel*"**. The aim is to eliminate the biological middleman (the plant), to more efficiently produce a sustainable oil.

To me, artificial photosynthesis is the Holy Grail of renewable energy. Where do we currently stand in this matter? Surprisingly, hardly a word is mentioned about this topic in the popular science literature. It is an idea which deserves far wider publicity and a massive injection of funding.

A number of groups around the world are looking into this matter including Lund University in Sweden; the Brookhaven National Laboratory, Arizona State and Boston Universities in the US and our own CSIRO (among others). The AAPN (Australian Artificial Photosynthesis Network) is a small multidisciplinary group of scientists in Australia and New Zealand who have a particular interest in this issue. I quote directly from their website: "*The primary photochemical conversion processes in nature…are much more efficient ( ~ 4 times) than the best silicon based photovoltaic systems. They have been highly 'refined' by evolution to extract the most from the spectrum of solar light flux received at the earth's surface. For this reason, we regard a program to develop chemically robust ,'biomimetic' photo-electric conversion systems,*

*as highly valuable*."[37]

To date progress has been modest, with the inefficient production of small volumes of hydrogen or methane at slow rates.

I believe however that research into artificial photosynthesis is much more likely to yield breakthroughs than the search for controlled nuclear fusion. After all, we have no precedent for the occurrence of controlled nuclear fusion under Earth-like conditions and it may never be possible to achieve this. Plants, however, have been quietly performing photosynthesis under ambient conditions for billions of years. We just need to discover how to mimic them. Surely it is not beyond human ability to find out how a primitive unicellular blue-green alga works.

**A metaphor**

Let me use a metaphor to describe our present situation. We are rapidly steaming ahead through dense fog on board a ship very much like the Titanic. Our radar indicates there is a huge iceberg directly in our path (the iceberg represents the impending industrial and agricultural collapse consequent to petroleum depletion, as well as the dire effects of global warming). The iceberg is half a mile away. Unfortunately we need two miles of seaway to stop our ship and our rudder is jammed, hence we cannot change course. Our captain (who represents America) used to be a benevolent and helpful fellow, kind to children and animals, but has recently been gripped by an aggressive madness. An Arab crewmate named Saudi recently slapped the Captain in the face (remember that in the September 11 hijackings, 15 of the 19 hijackers were Saudi nationals), so the Captain did the natural thing and beat up *another* Arab crewmate named Iraq to a bloody pulp. Those Arabs all look alike anyway, so he was fully justified. In any case, he needs Saudi to bring him his food.

We all know how to survive the impending collision with the iceberg: engage full reverse thrust to delay and lessen the impact,

and lower the lifeboats to save the passengers.

The Captain has at different times denied the existence of the iceberg on the radar or dismissed its importance - we can crash through it no problem, he says. Stoke up the boilers and full speed ahead. He claims it is all a left wing conspiracy, although he cannot explain how or why those shifty left wingers could or would fabricate such evidence.

We cannot overpower the Captain and take command. He has adopted a Rambo mindset and carries knives, guns and grenades on his person which he will not hesitate to use. We are either with him or against him, he says. All we carry are tiny nailclippers with spiky bits.

The first mate, Britain, who is currently stomping on Iraq's face with hobnail boots, has come to accept the existence of the iceberg but has done precious little except make a few token statements.

Some European crewmembers have begun to lower lifeboats and round up their favourite passengers.

Australia is a lowly midshipman who has always been loyal to the Captain. Despite our tiny stature, we have had the dumb good fortune to be blessed with morbid obesity. Our exuberant rolls of fat (representing our coal and uranium resources), serve as insulation and flotation, hence we will be able to survive much longer than anyone else in the frigid waters after the ship sinks. Complacency is thus the easy option for us. Let the others freeze and drown, why should we care? We'll be OK in the short term. However, we also have at our fingertips the operating handbook for the largest lifeboat of all, one that may save most, if not all the passengers. We just need to figure out the instructions for deployment.

What would you do?

**Conclusion**

At present, the only proven practical replacement for petroleum products in the transport industry is plant derived oils. Oil based

fuels are infinitely more user friendly than liquid hydrogen. We have the potential to greatly improve the economics of "*phytofuel*" production with the application of biotechnology. With adequate support and funding this can undoubtedly be achieved within a decade or two. "*Phytofuels*" alone however are unlikely to adequately meet our needs.

Success in artificial photosynthesis research is less certain, but it is much more likely to bear fruit than nuclear fusion research. Additionally, photosynthesis research can be undertaken without the need to construct multibillion dollar infrastructure facilities such as Tokomaks and is thus ideally suited for medium sized but highly capable economies such as Australia. It may take thirty to forty years to achieve the breakthroughs in "*photofuel*" development, assuming we embark on a concerted effort right here and now.

As individuals, the task ahead seems insuperable.

Can we persuade right wing Governments and Corporations with vested interests in fossil fuel consumption to acknowledge the Truth and to do the Right Thing? Some companies like BP have seen the writing on the wall and are actively investing in alternative energy research. Automobile firms like Toyota have achieved brilliant breakthroughs with hybrid engines. For others however (in particular the Bush and Howard administrations), trying to reason with them is a waste of time – they are intransigent, duplicitous, self serving and mutually support each other in powerful networks – as evidenced by past behaviour. They can be vindictive, bullying and resort to verbal gang bashing against those who may express an honest, valid but differing opinion[38,39]. John Howard said that developing nations such as India and China should be included in carbon emission agreements. Let us recall that America consumes seven times more fossil fuels per head of population than China (and Australia is not far behind). Advocating that *all* countries limit their emissions to 1990 levels (as per the Kyoto protocol) amounts to insisting that poor countries should be condemned to perpetual poverty, while rich countries, having historically burnt off more than their fair share of

fossil fuels in order to *become* developed, can continue to enjoy doing so. The aspirational impoverished of the world must surely view John Howard as a sanctimonious hypocrite with an overweening sense of entitlement. Fair minded Americans do exist, even if they have been sidelined and are only able to express themselves indirectly. In the Emmy award winning (fictional) TV series *The West Wing*, the Nobel prize winning Economist President Barlet said in one episode that a nation of SUVs has no moral right to lecture about reducing fossil fuel emmisions to a nation of bicycles.

The methods adopted by Detroit, the fossil fuel industries and their government proxies to discredit and deny the evidence behind global warming is reminiscent of the way the tobacco lobby vigorously endeavoured to cast doubt on the link between smoking and lung cancer. Their tactics and moral standards are identical.

I believe our best strategy is public education. Democracy can only work if a critical mass of voters possess a reasoned understanding of issues. We need to build grassroots support for policies promoting sustainable futures. All adults and children from perhaps age twelve need to be taught to think critically and must realise that there is nothing less at stake here than their future living standards, employment prospects, risk of global mass starvation and wars over resources. These ordinary folks are the ones we must recruit, who we ultimately depend on, to vote out useless lying-rodent politicians, to be replaced with courageous visionaries.

Photocopy this essay or print it out from www.rationalist.com.au (issue 70) and give it to your friends. Teachers or lecturers can use it to prompt discussion with their students. If you discover any inadvertent factual errors in your perusal, write in to the Rationalist to have them corrected, then disseminate the corrected version.

Let us dream of a future where human beings live sustainably and have minimal impact on the environment. A future where our descendants will look back and shake their heads in amazement at how greed, short term agendas, war mongering and wasteful

practices dominated our lifestyles and are thankful that they have found a better way.

R.L.L.

**References:**

1. Dr. Colin J. Campbell, Oil Depletion Analysis Centre, London http://hubbertpeak.com/campbell/

2. John Cassidy, *"Is energy independence an impossible goal?" the New Yorker*, 4 Oct 2004 (see also excerpt after reference 6)

3. Roland H. Worth Jr in his book, *"No Choice but War: The United States Embargo Against Japan and the Eruption of War in the Pacific"*

4. *"War on the Cheap", New York Times* Editorial, December 20, 2004: "From the earliest planning stages until now, the war in Iraq has been a tragic exercise in official incompetence. The original rationale for the war was wrong. The intelligence was wrong. The estimates of required troop strength were wrong. The war hawks' guesses about the response of the Iraqi people were wrong. The cost estimates were wrong, and on and on."

5. Sarah Boseley, health editor, *The Guardian*, 29 October 2004, quoting a study published in the medical journal *The Lancet*

6. From www.krysstal.com/democracy_whyusa_iraq.html : “Dick Cheney used to head Halliburton (the world's biggest oil-services company worth $18,200 million). From 1992 to 2004, Halliburton contributed $1,600 million to politicians. It was a co-sponsor to a measure to open the Arctic National Wildlife Refuge to oil drilling and voted against the Clean Water Act which required industries to release their toxic emission records. Since 1998, Halliburton has completed $24 million's worth of repairs to Iraqi oil pipelines. Dick Cheney, [who was put in charge of the National Energy Policy Development Group], has stated

that 'energy security should be the priority of USA foreign policy.'*(National Energy Policy report 01-NEPD4 , May 2, 2001.*)"

*"Is energy independence an impossible goal?", the New Yorker*, October 11, 2004:
"In 1999, when Cheney was still at Halliburton, he gave a speech at London's Institute of Petroleum in which he pointed out that by 2010 the world would probably need another fifty million barrels of oil a day. 'So where is the oil going to come from?' Cheney asked. 'While many regions of the world offer great oil opportunities, the Middle East, with two-thirds of the world's oil and the lowest cost, is still where the prize ultimately lies.'

7. *The 9/11 Commission Report*, (officially titled *The Final Report of the National Commission on Terrorist Attacks Upon the United States*) can be found at: http://en.wikipedia.org/wiki/September_11,_2001_Terrorist_Attack/Hijackers

8. Hugh Pope, Yaroslav Trofimov and Danny Pearl, *"Saudi Arabian Royal Family Finds Itself Caught in the Middle of Two Alliances", Wall Street Journal*, October 4, 2001

9. *"On U.S.-Saudi Relations. With us ... or against?" - San Francisco Chronicle* November 18, 2001

10. *"Putin signs Russia up for climate pact: Boycotted by U.S., Kyoto Protocol to take force in '05", MSNBC News Service*, Nov. 5, 2004 – http://msnbc.msn.com/id/6412133/

11. Karl Davies*, "Declining Oil Reserves: Some Key Concepts and Possible Consequences"* – http://www.daviesand.com/Perspectives/Forest_Products/Oil_Reserves/

12. Lawrence Berkeley National Laboratory, *"The ABCs of Nuclear Science"*: www.lbl.gov/abc/wallchart/chapters/14/1.html (updated 2004)

13. A. James Ruttenber et al, *"Report of Epidemiologic Analyses performed for Rocky Flats Production Workers Employed Between 1952-1989", Colorado Department of Public Health and Environment*: www.cdphe.state.co.us/rf/rfpworkerstudy/index.html

14. *"Plutonium cancer risk questioned", New Scientist*, 17 July 2004, page 12: "Plutonium may be many times more dangerous than previously thought. The cancer risk from exposure inside the body could be 10 times higher than is allowed for in calculating international safety limits."

15. Larry Johnson, *"Iraqi cancers, birth defects blamed on U.S. depleted uranium",* Seattle Post, Tuesday, November 12, 2002

16. Dr Chris Busby PhD, *"On the Biological Effects and Health Risks following Exposure to Aerosols produced by the use of Depleted Uranium Weapons",* Invited Presentation to the Royal Society, London, July 19th 2000

17. *"Fact sheet on the health effects of depleted uranium", US Department of State*, 7 October 2002

18. These figures can be found in any biochemistry textbook

19. Dr James J Eberhardt, *"Fuels for the future for cars and trucks", US Department of energy* 2002: www.osti.gov/fcvt/deer2002/eberhardt.pdf

20. Dr Robert Noland, Imperial College London, interviewed in *Focus* magazine July 2004, page 47

21. "Describing Scientific Uncertainties in Climate Change to Support Analysis of Risk and of Options" – Intergovernmental Panel on Climate change Workshop held in Maynooth, Ireland, 11–13 May 2004 – http://ipcc-wg1.ucar.edu/meeting/URW/product/URW_Report_v2.pdf

22. Global warming issues are elegantly summarised in the lead article of *Discover* magazine January 2005

23. "*Kyoto goes live – buying and selling carbon becomes big business", New Scientist,* 8 January 2005, page 29

24. Frederic Hauge & Marius Holm, *"Give carbon a decent burial", New Scientist,* 17 July 2004

25. John Michael Greer, *"The Coming of Deindustrial Society – A Practical Response",* October 5, 2004: http://www.hubbertpeak.com/whatToDo/DeindustrialAge.htm

26. *"All I want for Christmas is limitless energy without carbon emissions. Dream on"*, *New Scientist* Editorial, 4 December 2004, page 3

27. Jose Goldemberg et al, *Energy policy*, vol 32, p1141

28. *"A collection of articles on navy aviation in World War 2":* http://www.history.navy.mil/download/ww2-31.pdf.

29. Seventeen references from Chinese publications between 1935 to 1947 can be found at: www.aocs.org/press/inform/ref21101.asp

30. Numerous biodiesel referencess can be found at: http://www.frybrid.com/docs.htm

31. Professor Jared Diamond, "*Guns, Germs and Steel*" (Pulitzer prize winner for non fiction 1998), Chapter 7, pages 114-130

32. From: wwwscieng.murdoch.edu.au/centres/algae/BEAM-Net/BEAM-Appl2.htm

33. *"Why the future is hybrid"*, *Economist* magazine, December 4th 2004, pages 22-24

34. Solar energy group, University of Chicago: http://efi.uchicago.edu/nonimagingoptics..txt.html

35. Total surface area of the Earth = $5.1 \times 10^{14}$ $m^2$ Area required for solar energy collection = $5.1 \times 10^{14} / 2 \times 10^{4} = 2.55 \times 10^{10}$ $m^2$

= 25,500 km$^2$ which represents about 10% of the size of the Nullarbor Plain (which is about 250,000 km$^2$ in size)

36. Katharine Davis, *"Enough wind to power the world", New Scientist* 25 September 2004, page 12

37. From: http://www.aapnetwork.org/htm/home/artificialphotosynthesis.htm

38. Margo Kingston, *"Howard at end of credibility line on Iraq", Sydney Morning Herald*, March 16, 2004: http://www.smh.com.au/cgi-bin/common/popupPrintArticle.pl?path=/articles/2004/03/16/1079199216732.html

39. Joe Wilson/ Valerie Plame /Niger yellowcake affair, *New York Times* archives: http://query.nytimes.com/gst/abstract.html?res=F10C14F9345F0C778DDDA90994DC404482&incamp=archive:search and http://query.nytimes.com/gst/abstract.html?res=F20F1FFA3C5C0C7B8EDDA00894DC404482&incamp=archive:search