The emperor's new world

The only thing worse than a world run on oil is a world run without it.

There are four major factors behind higher oil prices: supply, demand, speculation and terrorism. Supply is restricted as oil becomes harder to find and process. Demand is still growing, largely due to the rise of China, which is now one of the world's largest users of oil. Knowing this, speculators recently poured onto the oil market, driving up prices beyond the wildest nightmares of many motorists. Oil prices have since retreated from their record highs, but few people expect oil to remain cheap into the longer term.

A fifth factor has compounded the problem: in recent years the American dollar has plummeted in value. With oil prices quoted in US dollars, this invariably pushed up the dollar value of each barrel of oil, which had a powerful symbolic effect at a global level. The more that oil was seen to rise in price, the greater the speculation and the greater the panic among motorists, businesses and governments alike.

Panic tends to produce panicked assumptions that don't always match reality. For example, analysts were recently predicting that global demand for oil could exceed supply by as soon as 2015. However, the situation is nowhere near as simple as that. First, the world isn't running out of oil; it's running out of cheap oil. There have been massive recent discoveries of both liquid oil and less conventional forms of oil. For example, Canada alone has around 180 billion barrels of recoverable oil from tar sands.

The problem is that a car cannot run off oil in the ground. The global oil shortage is a refining problem, not a lack of resources. As oil becomes harder to extract, it becomes more expensive. As oil becomes more expensive, major oil users look elsewhere for energy, or

> The waste left behind by nuclear power plants is going to be someone's problem for the next few hundred thousand years or so, long after the concrete bunkers built to house it have crumbled into dust

simply reduce their energy use. Oil is slowly running out, but it won't be in our lifetimes. Oil will remain a major global energy source for the foreseeable future, but only where there is no economic alternative.

The Chinese government is working hard to drop China's dependence on oil. Coal-fired plants may be crude and dirty, but they're cheaper to run than oil-fired plants and China is building them by the dozen. China is also investing heavily in nuclear energy, largely to break its dependence on oil.

So, will demand exceed supply in 2015? Almost certainly not. First of all, refining capacity for unconventional forms of oil is growing rapidly and will continue to grow as long as there is demand. The other dubious assumption underlying most predictions of a continuing oil shortage is that China's economy (and therefore its oil needs) will continue to grow at present rates.

Much of China's hunger for the world's commodities has been driven by sales of manufactured goods to the West, especially America. A flood of easy money, courtesy of the American Federal Reserve, was behind much of America's spending spree in China.

The easy availability of money at low interest rates fuelled a boom in housing and then domestic spending in America, as homeowners borrowed against the rising value of their houses. This boom flowed through to China as American homeowners, flush with borrowed money, bought desirable consumer items like flatscreen televisions. When the Chinese electronics factory got more orders for flatscreen televisions, it needed more employees and more energy. Thus, the Chinese economy boomed, along with its need for oil.

The American economic boom is now over, and the US housing market is in a state of collapse, along with many of the mortgage companies that made loans to the sub-prime mortgage market.

America's problems are now being shared with the rest of the world. Because the economies of the West are consumer-driven, any problems at the consumer end must have major flow-on effects at a global level. When consumers are having trouble meeting mortgage repayments, they are quite likely to defer buying a new flatscreen television from Walmart. When Walmart starts selling fewer televisions, they order fewer televisions from China. When the Chinese electronics factory gets fewer orders, it needs fewer employees and less energy. Thus, the Chinese economy cools, along with its need for oil.

At the time of publication, the Chinese government was artificially stimulating the economy to keep it from plunging into recession, but this form of artificial stimulation cannot continue forever: the laws of supply and demand must eventually prevail.

All of these factors point to a lowering of the global demand for oil and therefore less likelihood of severe price rises in the near future. But there's one factor that no one can control: terrorism.

If terrorists knocked out one major refinery, the effect would be immediate and drastic. Not only would the price of oil rocket because a major source of processed oil had suddenly dried up, but the threat of further attacks would probably trigger a further price panic that was out of all proportion to the actual interruption to supply.

This is well understood by both governments and terrorists, and a great deal of effort has gone in on both sides to thwart each other. To date the governments have won and there have been few major terrorist attacks to significantly affect oil supplies, but the threat is an everpresent one that will not really go away until either the terrorists are eliminated or alternatives to oil are found.

Oil installations in the Middle East are like war zones, with a massive military employed at all times to keep the refineries and pumping stations safe. Less safe are the installations outside the Middle East. Although American oil refineries are also protected, they are highly vulnerable to attack by a suicide bomber in a truck or aircraft. The Alaskan oil pipeline, when all's said and done, is nothing more than a large metal tube running a few metres above thousands of miles of empty tundra. A single stick of dynamite would shut it down.

So where does this leave the world's oil prices? While it is difficult to predict precisely, it seems likely that the analogy of a slowly tipping seesaw is most apt. Oil prices will stay high while China's economy remains bouyant, and then fall along with the Chinese and American economies. Terrorism will endanger global oil supplies and may drive prices back up again, not in a sustained pattern, but in a series of spikes, followed by equally dramatic drops as the threat diminishes.

In the longer term the ingenious human mind will find alternative ways of gaining sustainable energy. In the shorter term we can expect an uneasy seesawing of oil prices. Uncertainty seems set to be the norm.

Supply and Demand

It should be remembered that there is a huge difference between the short and long term availability of oil. There is plenty of oil still to be extracted, but you can't run your car on oil that's sitting 10,000 metres underground – it has to be processed and delivered to the consumer. Thus, any interruption to the processing and delivery of oil can have catastrophic effects, even if it's only for a short time. For example, Hurricane Katrina wiped out 25% of America's domestic production, causing crude oil prices to leap wildly.

Very high oil prices, even if they only stay high for a short time, can have a devastating effect on a country's economy. Not only does the country suddenly have to find more money to import crude oil, but high oil prices also tend to cause rampant inflation; virtually everything in the modern world relies on oil for much of its existence so high oil prices ripple through the economy. Trucking firms put up their prices because their fuel costs more. Supermarkets put up their prices because their transport costs have gone up. Workers demand higher wages to pay for higher fuel and grocery prices, and so on.

This is well understood by economists, of course, which is why even the threat of an interruption to supply is likely to trigger a sudden rise in the price of oil, even though it's only a threat. It's this threat to the steady supply of oil that is one of the major driving forces behind the desperate search for alternative forms of energy.

All Oil Isn't Crude

For the past 100 years of so, crude oil has been cheap and easily extracted. However, the oil that comes gushing out of the ground isn't the only oil around. One of the largest sources of oil on the planet is shale oil.

Shale is basically a type of rock and shale oil is oil that is trapped inside shale. Known shale oil reserves are vast, especially in the US, but the amount of oil in the shale varies wildly and a comparatively small amount of the accessible shale can be easily processed. The rest will only become economically feasible if the price of crude oil continues to rise and/or if the extraction methods improve. All oil processing pollutes, but the processing of shale oil is particularly messy.

The problem with alternative forms of oil – like shale and tar sands – is that extracting the oil takes far more energy than extracting and processing conventional crude. At some point, the energy used to extract the oil from shale or tar is greater than the energy you derive from the oil at the other end of the process.

Oil/Tar Sands

Canada's oil sands offer similar benefits and challenges to shale oil. The term 'oil sands' loosely describes a soup of water, bitumen (which is essentially solidified crude oil) sand, and other minerals. The term 'tar sands' is also sometimes used. The huge Athabasca oil sands have been successfully producing crude oil since 1967, but has received an enormous boost from recent high crude prices.

A few years ago, Alberta's government astonished the world by estimating that its oil fields were capable of producing 174 billion barrels of oil, making Canada the world's second largest oil producing country. Even this estimate may be conservative, as oil extraction methods are continually improving and new fields may be found.

Venezuela's Orinoco oil sand reserves are potentially even bigger than Canada's and the oil is easier to extract.

Like shale oil, oil from tar sands is both energy-intensive and highly polluting.

Coal Oil

Another source of oil is coal. Coal can be fairly easily converted into crude oil but the process is costly and is only really economic when the price of oil is high. As with shale oil, converting coal to oil is also harsh on the environment.

New Avenues

Oil prices go up and down as supply and demand ebb and flow, but in the longer term the usable supply is shrinking, which means the price must stay high until a feasible alternative is found.

Over the last hundred years or so we have become more and more clever at finding energy in distant places, so it seems natural that as one source of energy runs out, another will take its place.

This has not proved to be the case: there are currently two main forms of energy on the planet (fossil fuels and electricity) and they were already in use at the turn of the last century. Coal and oil can be burnt by themselves – to heat homes and run cars – but electricity has to be generated.

The major forms of energy on the planet are all derived from sunlight. Even nuclear energy is essentially fossilised sunlight.

Of the four major sources of energy (coal, oil, hydroelectric dams and nuclear reactors), the last two are only of value when converted into electricity. Thus, when you hear governments talk about alternative forms of energy, you should keep two facts in mind:

1. There are currently no easy alternatives to the four sources of energy described above.

2. The world's energy needs are currently going up, not down.

It's easy to be hypnotised by technologies like wind and solar power. The reality, however, is that for the foreseeable future both these technologies will remain secondary electricity generation methods. Although wind and solar technology are both improving all the time, they simply don't produce enough electricity at present to compete with existing technologies. The same applies to virtually all the 'alternative' forms of energy that are currently grabbing the headlines.

In countries like New Zealand there is abundant rainfall that is used – via the rivers it flows down – to generate clean hydro-electricity. Yet even New Zealand is facing an electricity shortage as the demand for electricity grows but the supply barely keeps up. Despite New Zealand's clean, green image, nearly one third of its energy is produced by burning fossil fuels. New

Zealand also has abundant wind suitable for generating electricity, but no one expects this source of energy to be a major contributor to electricity generation in the immediate future. It's a useful top-up for the national electricity supply. That's all.

Now consider countries like Australia, which faces the same problem as most of the world. Although parts of Australia have good sources of water for generating electricity, the fact remains that much of Australia's electricity is generated using very dirty fuels. Of the 550 million tonnes of carbon dioxide emissions produced by Australia in 2003, 25 million tonnes came from road transport and 190 million came from electricity generation.

However useful electricity is, there is barely enough supply even in countries with cheap ways of generating it. There are currently no quick and clean solutions to substantially increasing electricity generation to make up for the gap left by oil.

There's a glimmer of hope through emerging technologies, such as sea power (generating electricity through the harnessing of waves or tidal currents). However, as things stand, these are relatively minor players in an energy-hungry world. It's worth noting that no one, to date, has ever produced a successful long-term full-sized generating plant using the power of the sea. The ingenious human mind may be able to solve the huge problems posed by electricity generation using sea power, but it is unlikely to be cheap or to happen in the near future.

False Prophets

There's hardly a day goes by without an exciting new alternative energy source being announced in the news media. Like miracle cures for cancer, most of these alternative energy miracle cures fail to deliver on their promises.

The problem with most of the 'answers' to the global energy crisis and climate change is that the scientists who came up with them were asking the wrong question. From an objective point of view, the right question to ask was: "How can we, as a planet, adapt to a world where energy is no longer cheap and our actions are severely impacting on the planet?"

Most objective scientific research suggests there's no quick fix to either the energy crisis or climate change. In the longer term, we're all going to have to use less energy, and that means smaller houses, less plastic junk that we don't really need and less wasted trips in our cars.

Instead of facing these grim facts, however, the question that is usually asked is: "how can we, as a planet, maintain a twentieth century American lifestyle using alternative energy sources?" The answer, of course, is: we can't. There simply aren't enough resources of land and energy around, no matter how you reshuffle the figures.

Because the wrong questions are being asked, we are continually getting dubious answers. The world is demanding quick-fix solutions to the problem, so that's where all the research dollars are going. The results of this research produce great headlines, but a closer examination of the solutions these scientists are coming up with suggests that most forms of alternative energy are like the emperor's new clothes.

For the last hundred years, the world's economy has been based around cheap energy. However, this cheap energy is gone, and none of the alternatives to oil come close to meeting the world's future energy needs unless we drastically reduce our consumption at a global level.

Technologies like biofuels currently offer a perceived benefit, and little else. Globally biofuels are driving food prices so high that poor people in developing countries can no longer afford to feed their families. People are currently starving to death so that Western motorists can sit in traffic jams on their way home from work.

The fantasy behind much of the alternative energy movement says that it's going to be possible to continue the Western lifestyle of the twentieth century by changing the fuel used to power it. That's a bit like trying to lose weight by switching from hamburgers to french fries. The basic problem is never addressed.

'Green' Coal

Some modern coal plants are more efficient and less polluting, but the costs of achieving this improvement are very high. Many older plants cannot be retrofitted with the cleaner technology because they were not designed to allow for such upgrades.

Australia, like most of the Western world, is heavily reliant on old, messy coal-fired power plants. Despite years of attempts by the coal power industry to paint itself as progressive and 'green', little real progress has been made.

On 6 July, 2008, *The Age* reported that:

"...the spin on clean coal is wearing thin. Despite millions of dollars of taxpayer investment, the costs of retrofitting Victoria's four brown coal power stations with technology to make them cleaner could be so high it might be cheaper to build new ones or convert them to natural gas."

Even with new technologies, some environmentalists are openly sceptical of 'green' coal technologies. It has been widely reported in the news media that, in the near future, CO_2 from burning coal will be pumped into giant underground caverns. This process, known as 'CO_2 trapping', will make coal 'green', says the coal lobby. Unfortunately the technology doesn't actually work at present and is unlikely to work in the foreseeable future.

Firstly, the caverns where the CO_2 might be pumped are rarely close to a coal-powered station. Therefore the CO_2 would either have to be pumped along gigantic pipelines or carried by train or truck, at enormous cost. There's also no guarantee once the CO_2 is pumped underground, that it's going to stay there.

When asked by the *New York Times* how far the CO_2 trapping strategy was going, Daniel M. Kammen, Director of the Renewable and Appropriate Energy Laboratory at the University of California, Berkeley, replied: "It's a total mess."

The U.S. government has pumped about $40 million into FutureGen, a project that was supposed to provide a roadmap for CO_2 trapping. However, in January 2008, the "government pulled out after projected costs nearly doubled, to $1.8 billion. The government feared the costs would go even higher. A bipartisan effort is afoot on Capitol Hill to save FutureGen, but the project is on life support."

Solar Power

Regrettably, due to the cost of solar panels and the difficulty in harvesting the sun's rays, solar power costs more to harness than existing technologies. In other words, solar power is generally only feasible if it's subsidised.

Although the technology for harvesting the sun's rays is getting better, the fact remains that it is very hard work to make electricity this way. There's also the problem that you can only get electricity from the sun when the sun is actually shining. When the sun goes behind a cloud the electricity production plummets and at night there's no production at all. Thus, in order to make use of solar power, you have to have a range of other ways of making power as well, or the power goes off at sunset.

Australia had planned to build one of the largest solar power stations on the planet. However, in 2009, the plant's owner, Solar Systems, went into receivership and work on the plant halted. This is unfortunate, but the plant wouldn't have made much difference anyway. The AU$420 million Victoria station was expected to produce 154 megawatts of electricity, or enough to power 45,000 homes. This sounds really impressive until you realise that 45,000 homes represents one small city with no heavy industry.

Scientists at the Massachusetts Institute of Technology (MIT) have successfully created a sophisticated, yet affordable, method to turn ordinary glass into a high-tech solar concentrator, or so the headline went. However, at the bottom of the press release, and far less widely reported, was the phrase: "However, the current technology still needs further development to create a system that will last the 20-30-year lifetime necessary for a commercial product." In other words, the technology doesn't currently work and, if the press release is anything to go by, won't be working commercially in the immediate future.

Perhaps sometime soon scientists will overcome the problem of effectively harnessing and storing energy from the sun's rays. Perhaps in five years vehicles powered by solar panels on the roof might be a reality, but there are many significant obstacles to overcome in the meantime.

Wind Power

Wind power currently accounts for around 1% of the world's electricity needs. Some European countries produce more – Germany produces 7% and Denmark 18% of its total electricity needs from the wind.

Wind-powered generation is plagued by high startup costs and unreliability (if the wind stops, so does the power). Significantly, the coastal regions that are ideal for wind generation are often also popular places for people to live. Thus there are frequent objections to the building of wind generators on most coastal land, with noise, appearance and the threats to birdlife being common objections.

A more hopeful solution is to build wind generators offshore, where winds are steadier and objectors few. However, offshore generators cost more, are more susceptible to corrosion due to salt, more expensive to maintain and face the problem of getting the electricity back to shore.

In his book *Renewable Energy Cannot Sustain A Consumer Society*, scientist Ted Trainer pointed out that many pioneering wind generation plants were sited in near-ideal locations. Therefore, he argues, it is unreasonable to assume that subsequent locations will be anywhere near as ideal. This raises questions about the optimistic estimates of potential wind generation, many of which tend to emanate from interest groups and commercial interests.

Trainer also questions many of the assumptions about the space requirements for wind farms: "A wind system [capable of reliably producing the] equivalent to that of a 100MW coal-fired power station would occupy 2,200 square kilometres."

Moreover, there are currently considerable difficulties getting the energy from the wind farms to the consumer, caused by the problems of long distance power transmission.

Like solar power, wind power is mainly a supporting technology to existing forms of generation. It survives largely on government subsidies and in an open marketplace would face an uncertain future.

Tidal Power

Suitable sites for new hydroelectric projects are relatively scarce in the West, and opposition to new generation stations is frequently fierce, meaning that hydroelectric power generation is unlikely to substantially increase, or to increase only slowly. The use of sea power for hydroelectric generation is an exciting new development, but is currently barely commercially feasible, due to the extreme environment in which the generating equipment must operate. Assuming that the current technical hurdles can be overcome, it seems clear that electricity generated by sea power is likely to be significantly more expensive than conventional hydroelectric power.

Tidal power has been used for power in the form of mills since the Roman Empire. However, the use of seawater to generate electricity has inherent problems: whereas fresh water is relatively non-corrosive, sea water is aggressively corrosive to most metals. In addition to the corrosion caused by the water itself, wind-blown salt spray contaminates electrical fittings and causes corrosion far removed from the water itself.

The biggest wave farm currently in use is in Portugal and produces 2.25MW; there are plans to increase this to 21MW by simply expanding the facility with more of the same.

The cost of a proposed 3MW wave farm in Scotland is estimated to be around 4 million pounds.

According to the president of trade association Ocean Renewable Energy Coalition, "The total potential off the coast of the United States is 252 million megawatt hours a year." Which works out to a constant 28,000MW of generation.

Whereas river-based hydroelectric stations are generally dealing with water that flows consistently in one direction only, sea-based systems are dealing with water that flows in two directions or more on a regular basis.

Because the sea often becomes violently turbulent during storms, maintenance and repairs during these times are likely to pose serious logistical and safety problems.

Sea-based generation currently produces only a tiny percentage of the world's electricity production, and this is unlikely to change in the immediate future. Even if the considerable technical problems associated with sea-based generation can be overcome, electricity produced this way is likely to be considerably more expensive than electricity generated by conventional systems.

When Bill Reinert, the manager of American Toyota's Advanced Technologies Group, was asked how long it would take for hydrogen-powered cars to replace petrol-powered cars, he replied, "If I told you 'never,' would you be upset?"

Hydrogen

According to former US President Bush, hydrogen is the fuel of the future. Every major car company has announced hydrogen-powered vehicles and many have shown actual working models. All that is required – according to media releases – is a few thousand filling stations and a few trillions in taxpayer dollars to overcome 'technical difficulties'.

When Bill Reinert, the manager of American Toyota's Advanced Technologies Group, was asked how long it would take for hydrogen-powered cars to replace petrol-powered cars, he replied, "If I told you 'never,' would you be upset?"

Many scientists are now equally sceptical that hydrogen can ever be a feasible alternative to petrol. In 2005, Ralph J. Cicerone, president of the prestigious American National Academy of Sciences, told the US Senate that there were: "substantial technological and economic barriers in all phases of the hydrogen fuel cycle."

A 2007 panel of scientists, engineers and industry experts assembled by the National Academy of Sciences concluded that the hydrogen economy remains little more than a dream. Joseph Romm, a physicist who led a study into alternative fuels for former US President Jimmy Carter, was even more blunt:

"A hydrogen car is one of the least efficient, most expensive ways to reduce greenhouse gases. If you want to slow down global warming, you're not going to do it with a hydrogen car… not in our lifetime, and very possibly never."

Hydrogen's most passionate advocates see hydrogen production as a way of using off-peak electricity to power cars. This electricity, of course, is mostly produced by nuclear power, burning coal, oil or in hydroelectric dams, so little real benefit is likely.

One should bear in mind that hydrogen is not a form of energy; it's a means of storing energy. Hydrogen acts as a bank account: the bank account doesn't produce the money, it simply stores it. For every hundred dollars you put into your energy bank account you get a percentage back. Although in theory you could produce hydrogen at up to 90% efficiency, real world efficiency is as low as 50%. In other words it is like putting $100 into a bank account and getting about $50 back: it doesn't represent value for money.

Scientists around the planet are trying to solve this problem, but with the best will in the world, they're only going to reduce the losses, not stop them. Thus, in an ideal world you might even get $90 back for every $100 you put into your hydrogen account, but you would still have to have the energy in the first place.

Natural Gas

There are still vast reserves of highly inflammable natural gas. Australia in particular has enough liquefied petroleum gas (LPG) to last for many years, even with vast amounts being exported.

LPG is clean burning and thus emits less pollution. It's currently cheaper than petrol. All you need to drive using LPG is a tank to store it in and a conversion to allow your car to run on it.

There are problems. Firstly, the conversion is expensive and you have to be driving a high mileage before it makes economic sense. Secondly, you lose around 30% of the engine's power, simply because LPG has less energy than the equivalent amount of petrol. Thirdly, despite claims to the contrary, LPG appears to damage some engines. This is less of an issue with many modern conversions; carmakers like Ford have introduced factory conversions that appear to have solved many of the problems of engine damage.

Lastly, there's the issue of safety. LPG is extremely inflammable and under the right circumstances can turn a car into a bomb. That's why most conversions require a safety certificate.

However, the biggest problem with LPG is simply that it's a fossil fuel, like petrol. LPG may be cheaper than petrol, but when the price of petrol goes up, so does LPG, generally. Another factor likely to drive the price up is taxes: at present many countries encourage the use of LPG by taxing the LPG at a lower rate than petrol. However, as time goes by the tax on LPG is likely to rise to a similar level to other fossil fuels, making it less attractive.

Natural gas, while currently plentiful, is a fossil fuel and must one day run out. While estimated global natural gas reserves are 6,182.69 trillion cubic feet, natural gas production is constrained by the extreme danger inherent in collecting and transporting it.

Natural gas in distant countries (and in difficult geographical locations) carries a high cost of containment and transport. Also, there has been an increased demand for natural gas due to the oil shortage. These two factors must inevitably combine in the longer term to substantially raise the cost of natural gas.

Given the increased demand likely to be driven by a need for cleaner fuels than coal, the long-term outlook for natural gas is that it will remain an expensive option for electrical generation. While natural gas-powered stations are able to respond much more quickly to sudden energy demands, natural gas is expensive and therefore power companies are often reluctant to use it unnecessarily.

Biofuels

Biofuels are fuels produced from plants and animals. There are three main types – ethanol, biodiesel and plant-derived crude oil.

Like all the other miracle solutions to the energy crisis, biofuels have thusfar failed to deliver. To date, biofuels have arguably caused more harm than good.

At its most cynical, the current biofuels movement is simply a get-rich-quick scheme promoted by unscrupulous multinational corporations, and the whole world is paying the price.

Ethanol

Ethanol is a form of alcohol, produced by fermenting plant or animal matter. Ethanol is an attractive concept, because it appears to offer an endless supply of cheap fuel, but the reality does not currently match the expectations.

The first problem is that ethanol has far less energy than petrol – you need much more of it to do the same job. Secondly, ethanol is hard to store because it absorbs water and cannot simply be put into big tanks like petrol. Thirdly, ethanol, at least in most Western countries, is, at best, only marginally economic to produce. For example, in America ethanol is made from fermented corn, in quite a similar way to moonshine whisky.

The amount of energy going into growing, fertilising, harvesting and processing the corn into ethanol currently exceeds the energy you get back out the other end. And, unfortunately, much of the energy used in this process comes from oil.

To put it another way, ethanol is an expensive way of wasting fossil fuels. Americans would be better off simply burning the fossil fuels in cars rather than going through the complicated and wasteful procedure of converting it, through corn crops, into ethanol. There's an equally disturbing side effect: there's only so much land available for growing food, and if enough land is growing corn to make ethanol, then there may not be enough space left to grow corn for humans.

There's a lot of research going on right now to find alternative crops from which to make ethanol, but they're a long way from being commercially feasible, with one exception.

Ethanol makes more sense in countries like Brazil because Brazil is a major producer of sugar cane. Brazil has been using alcohol as fuel for decades, so there's already a great deal of expertise. Ethanol makes up 20% of Brazil's transport fuels. Even allowing for the fact that ethanol gets fewer kilometres per gallon than petrol, it's still cheaper for the average motorist.

As a result of its much criticised state funded ethanol development programme, Brazil is now one of the few nations in the world that is getting close to energy self-sufficiency. Ethanol – a clean burning fuel – has also resulted in a steady reduction in pollution in Brazil's cities. 70% of new cars sold in Brazil are flex-fuel, that is, they can run ethanol, petrol, or a combination of both.

Naturally, both the Brazilian government and the companies making the biofuels say that there's no environmental downside to the programme. This is not strictly true. Firstly, much of the existing cane plantations are grown on land that was once dense forest. Because dense forest absorbs far more CO_2 than cane fields, even the existing plantations are contributing to climate change.

Secondly, a large percentage of the new cane plantations are taking place on land known locally as Cerrado. The World Wide Fund for Nature (WWF) has described Brazil's Cerrado region as one of the richest savannas in the world. "The ecoregion includes one of the most diverse and intact tropical grasslands on the planet."

The Cerrado is also home to around 5% of Earth's total flora. It is also a vast carbon sink, said to be absorbing greenhouse gas emissions at a far greater rate than sugar cane.

According to WWF, "Agricultural expansion… and water projects pose major threats to the Cerrado."

South American-based journalist Chris McGowan is even more pessimistic:

"Biofuel production will directly impact the Cerrado as sugar cane and soybeans replace native vegetation. [Biofuel production will also] indirectly affect [the Cerrado] as cattle ranching and soybean farming (for food) moves there, after being displaced [from existing farmland] by today's highly lucrative ethanol business."

McGowan is also deeply concerned by what he sees as biofuel's threat to the Amazon River region, which accounts for approximately 1/5 of the world's total river flow and more than one third of all species in the world.

"The Amazon will be affected by the biofuel boom both directly and indirectly. Biofuel crops such as soybeans and palm oil (both used to make biodiesel) are grown on a large scale there. And, contrary to what [Brazilian] President Lula and some others have claimed, cane is indeed cultivated there. In July, Brazilian authorities raided an Amazon sugar cane plantation, in which 1,000 labourers were found working in horrendous debt-slavery conditions. The company, Para Pastoril e Agricola SA, grows cane for ethanol on a 10,000-hectare (24,700 acre) plantation in Pará state, in the Amazon."

"Brazil's Agriculture Minister Reinhold Stephanes has announced that Brazil will restrict the planting of sugar cane in the Amazon and Pantanal in the next few years."

However, adds McGowan: "the [current] administration does not have a noteworthy environmental record."

A New Zealand company – Fonterra – is making ethanol from whey, a waste product from the dairy industry. However, Fonterra refuses to say whether the process is economically viable, quoting commercial sensitivity. Also, while the use of this ethanol will slightly reduce New Zealand's emissions of greenhouse gases from cars, this reduction is small compared to greenhouse gas pollution produced by the New Zealand dairy industry. Greenhouse gases from dairy cows have increased 70% since 1990 while emissions from nitrogen fertiliser – largely due to dairy farm expansion – has increased 500%. It's also worth noting that nitrogen fertiliser is almost always synthesised from fossil fuels.

Biodiesel

Biodiesel is diesel fuel produced from animal or vegetable matter. In recent years there have been numerous reports of ingenious and smug motorists running their vehicles on used fast food oil. This is an interesting distraction, but in reality, all cooking oil is expensive and waste cooking oil is already in high demand for making other things, such as soap.

Biodiesel is fuel that can be pumped straight into a diesel-powered vehicle, usually without the vehicle having to be modified.

Most waste fast food oil is not biodiesel; it's waste vegetable oil. Even though some diesels can run on it, most can't without modification. The same applies to ordinary vegetable oil, known as Straight Vegetable Oil (SVO).

Much of the fuel being described as biodiesel is not actually biodiesel; it's straight diesel fuel blended with a percentage (5–20%) of straight vegetable oil. Typically these mixes have a B at the front, followed by a number, so B20 means that the fuel contains 20% vegetable oil.

Most commercial biodiesel is made from either RME (rapeseed methyl ester), PME (vegetable methyl ester) or FME (fat methyl ester), meaning that it can be made from either vegetable or animal fat products.

Compared to ethanol, biodiesel is far more efficient: one gallon of biodiesel produces about the same amount of energy as 2.25 gallons of ethanol. Biodiesel is also much kinder to the environment than conventional diesel when it is burned. Pure biodiesel will generally run without problems in any existing diesel engine, but on older engines it may damage rubber parts.

Pure biodiesel has the disadvantage that, in very cold temperatures (–10°C), it will turn to jelly, which can lead to problems with starting the engine at such temperatures. There are various fixes being tried for this problem. Biodiesel has other problems: it absorbs moisture, which can damage internal components in the engine and fuel system. It may also cause the growth of microbes in the fuel, which may eventually clog the system. Water in the fuel also causes poor burning of the fuel, which means less power and more pollution.

The technical problems with biodiesel will doubtless be solved with time. However, there are more pressing issues relating to supply.

Despite America's predilection for junk food, used cooking oil is a drop in the ocean when it comes to supplying the America's transport needs. According to a report from New York's Cornell University:

"[Used cooking oil] has an available potential to produce almost 1.7 billion gallons of [biodiesel] [which is] 1.1% of [America's] petroleum imports today."

(A litre of cooking oil does not give out a litre of biodiesel. Much of the cooking oil used to cook French fries is eaten as part of the fries and much of the waste cooking oil left over is unusable solids.)

Because of the shortage of used cooking oils for conversion to biodiesel, there is a global race to produce vegetable oils to meet the demand. This demand has driven up food prices, making it much harder for poor people to feed their families. Also, forests are being cleared to grow crops like palm oil for biodiesel, meaning that some biofuels are actually contributing to global warming by removing forests that would have absorbed CO_2.

Biodiesel critics estimate that: "every ton of palm oil generates 33 tons of carbon dioxide emissions – 10 times more than petroleum."

The international biofuels industry is being sustained mainly by government subsidies. In other words, the taxpayers in those countries are paying to produce 'green' fuels that often result in severe environmental damage, aren't cost effective, drive up the price of food and contribute to political instability in the Third World.

Rays of hope

There are a few rays of hope: a number of experiments are currently being conducted to produce biofuels that are more energy-efficient and less destructive.

For example, several companies have successfully converted algae sludge into crude oil. The process is not new; it's been tried and abandoned many times before, but the technology for converting algae into fuel is getting better all the time and may become economically feasible in the near future.

There are lots of benefits with algae: it's the most abundant form of plant life on the planet. It can be cheaply and easily grown at a rate of up to 100 tonnes per acre, per year. Even better, algae production does not displace human food crops. It can be grown in places such as sewage treatment ponds and has the positive side effect of purifying the water in the process. It also absorbs CO_2 and releases oxygen.

Jatropha – a group of approximately 175 succulent plants, shrubs and trees – is also showing increasing promise as an alternative source of energy. Because it grows rapidly, has a high oil yield and can grow on marginal land that would not be used for food production.

However, jatropha is not quite the miracle it appears; the seeds are highly poisonous and one species of jatropha has already been banned in Western Australia because it is invasive and highly toxic to both people and animals.

Moreover, in a world where wars may be fought over water, jatropha is a moisture thief. Reporting in a recent issue of the Proceedings of the National Academy of Sciences, scientists from the University of Twente in the Netherlands concluded that jatropha consumes five times as much water per unit of energy as sugarcane and corn, and nearly ten times as much as sugar beet – the most water-efficient biofuel crop.

Study co-author Arjen Hoekstra concludes: "The claim that jatropha doesn't compete for water and land with food crops is complete nonsense."

Although jatropha can indeed be grown in areas of low rainfall, to flourish, the crop needs large amounts of water. "If there isn't sufficient water, you get a low amount of oil production."

A second study, carried out by Friends of the Earth, concluded that – contrary to claims by promoters of jatropha – jatropha plantations in Swaziland run by BP and D1 Oils, were taking land and water away from food crops in a country already suffering from chronic food shortages.

The same thing happened in Myanmar, where jatropha was semi-forcedly planted on land formerly used for crops, in a mad attempt to promote independence from imported oil. The *Wall Street Journal* reported that:

"Myanmar's badly conceived agricultural policies are compounding the country's already dire food situation."

The bottom line with ethical biofuels is this: despite the many hopeful experiments being conducted around the planet, most projects are years away from producing commercial quantities at affordable prices.

Moreover, even though this technology is a step in the right direction, there seems little prospect of ever producing really cheap biofuels. Affordable, yes, but not cheap. Cheap fuel is what powered the world's economy for the twentieth century, so these new-generation biofuels will not so much solve the energy crisis as make it more bearable.

Nuclear Power

The remaining source of energy – nuclear power – has a poor safety record and a sombre, enduring legacy.

Since their invention nuclear power stations have been enthusiastically touted as the solution to the world's energy problems, but like so many miracle cures, the reality has not always matched the hype.

As the first nuclear power plants were being built in the mid-1950s, the chairman of the United States Atomic Energy Commission enthusiastically predicted that nuclear power would be so cheap to produce that it would hardly be worthwhile charging for it. He further predicted that 1000 nuclear power plants would be powering America by the year 2000.

Alas, no. From the start there were problems. The predictions of the cheap cost of nuclear power were unrealistically optimistic. This is because the figures used to justify the building of nuclear power plants assumed that the plant would produce maximum levels of power, 24 hours a day, 365 days a year. There have also frequently been massive cost overruns in building the plants, maintaining the plants and cleaning up the mess after the plant closed down.

Despite the promises, nuclear power plants rarely operated at full capacity. Moreover, the time lost in maintenance, refuelling and repairs meant that they were actually producing around half of the predicted electricity, and even then, not all the time.

Minor and more serious accidents were frequent from the beginning, but the owners saw these as teething problems. It wasn't until the serious accidents at Three Mile Island in America in 1979 and at Chernobyl in Russia in 1986 that the world began to lose faith in nuclear power.

Exactly how many lives were ruined by the above incidents is hard to tell. At the time many governments and much of the scientific community were enthusiastic supporters of nuclear power. It is likely, therefore, that they were blindly or deliberately optimistic in their analysis of the health effects of both disasters.

Speaking of the Chernobyl disaster, the Associated Press reported:

"Researchers trying to determine death tolls – and predict deaths still to come – don't have an easy task. Soviet-era attempts to cover up the chaotic and often inhumane response made it difficult to track down victims. Lists were incomplete, and Soviet authorities later forbade doctors to cite 'radiation' on death certificates."

However, in 2006 the Ukrainian Health Minister claimed that 2.4 million Ukrainians had health problems resulting from Chernobyl. Other reports have suggested that the casualty rate was minimal. The truth, as usual, probably lies somewhere in between. However, few of the people who are currently enthusiastically promoting nuclear power as the solution to the world's energy crisis seem enthusiastic about having a nuclear power plant anywhere near where they live.

The biggest problem in assessing the risks of nuclear radiation is that – in low doses – it generally doesn't kill people outright. Moreover, it affects different people in different ways. Pregnant women, for example, are extremely vulnerable to even small doses of radiation because of the likelihood of birth defects. A healthy man, however, could be exposed to radiation and show no signs of harm for decades.

It also depends on how the radiation is absorbed. For example, there is credible evidence that the use of depleted uranium by the US forces in Iraq may be causing immense health problems among veterans of the two Gulf wars. The problem – it appears – is not that the soldiers were exposed to high levels of radiation; the problem is that they breathed radioactive dust left behind by the uranium-tipped weapons. The Australian documentary *Blowin' in the Wind* interviews a number of ex-US military personnel who make it pretty clear that their government has actively sought to suppress evidence of health problems associated with depleted uranium.

It's often extremely difficult to pin down what causes people to get ill or die. For example, alcoholics frequently die of conditions like pneumonia. You can't say that alcohol causes pneumonia because there's no direct link. You can, however, say that a lifetime of alcohol abuse makes a person highly susceptible to other health problems, of which pneumonia is one.

The same applies to nuclear power. Did the old woman get pneumonia and die because she was exposed to nuclear radiation after Chernobyl or because she lived in a cold country? Did the old man in Pennsylvania get lung cancer because of radiation from Three Mile Island, or because he smoked? No one can say for sure.

The critics of nuclear power say that, with time, clear causes and effects of exposure to nuclear radiation do show up, but, like lung cancer among smokers, by the time you realise the link, it's too late. The damage has already been done and can't be undone.

Naturally, the nuclear power industry sees no problem with the safety of its products, but it's worth looking at the track record of similar corporations. For fifty years the America tobacco, asbestos and lead industries waged a brilliantly successful media campaign, convincing both the public and the government that their products were both safe and socially desirable. It's hard to believe nowadays, but in the late 1940s, a major American tobacco company was able to get away with the slogan: "More doctors smoke Camels than any other cigarette."

Even more amazingly, the petroleum industry managed to convince the world that it was safe and desirable to add lead – a proven and potent neurotoxin – to petrol in order to make cars run smoother. Thus, for around 50 years, the air around the world's roads filled with the residues of millions of tons of lead that belched out the back of almost every car. So much lead was released in the process that even in underpopulated countries like New Zealand, the land beside a major public highway was once declared to contain enough lead to be economic for mining. Needless to say, advocates like Standard Oil pronounced lead as "a gift from God."

Perhaps the nuclear power industry is different. Perhaps not. High costs and the perceived threat to human life have kept new nuclear power plants at bay until the recent energy crisis suddenly pushed them back onto the agenda. A new reactor – the world's largest – is currently being constructed in Olkiluoto, Finland and many more possible plants are being built or considered around the world. However, things are often not going according to plan: for example, the Olkiluoto project is 50% over budget and several years late.

This pattern is being repeated all over the world, to the extent that Moody's credit rating agency has warned US power companies that they risk a credit rating downgrade if they build new reactors.

There are also large numbers of existing plants: 20% of America's electricity is currently produced in 104 nuclear power facilities. France is highly dependent on nuclear energy, with nearly 80% of its electricity produced using nuclear reactors.

There's no quick fix to either the energy shortage or global warming. In the longer term, we're all going to have to use less energy, and that means smaller houses, less plastic junk that we don't really need and less wasted trips in our cars

In August of 2009, the *Christian Science Monitor* reported: "Altogether, nuclear-industry bailouts in the 1970s and '80s cost taxpayers and ratepayers in excess of $300 billion in 2006 dollars, according to three independent studies cited in a new nuclear-cost study by the Union of Concerned Scientists.

New guarantees in coming years could also leave US taxpayers picking up the tab if nuclear utilities default on their loans. In 2008, the Government Accountability Office said the average risk of default on Department of Energy guarantees was about 50%. The Congressional Budget Office projected that default rates would be very high – well above 50%.

On that basis, the potential risk exposure to US taxpayers from federally guaranteed nuclear loans would be $360 billion to $1.6 trillion, depending on the number of power reactors built, the Union of Concerned Scientists' study found.

"You want to talk about bailouts – the next generation of new nuclear power would be Fannie Mae in spades," says Mark Cooper, senior fellow at Vermont Law School's Institute for Energy and the Environment. Dr. Cooper is among several economic analysts who contend that – waste and safety issues aside – nuclear energy is too costly.

"Funding nuclear power on anything like the scale of 100 plants over the next 20 years would involve an intolerable level of risk for taxpayers because that level of new nuclear reactors would require just massive federal loan guarantees," says Peter Bradford, a former member of the Nuclear Regulatory Commission and former chairman of the New York State Public Service Commission.

Nuclear power plants produce electricity by using atomic energy to boil water. This water turns to steam and the steam makes a wheel turn and the turning wheel generates electricity. The advantage of nuclear power is that atomic energy can generate a great deal of heat over a long period of time, thereby providing a long-lasting, stable form of fuel from which to generate electricity. The downside is that nuclear energy is extremely difficult to control and is incredibly dangerous to humans nearby. In order to control the tiny amount of nuclear fuel that powers a power plant, a massive structure is required to cool and otherwise regulate the nuclear activity. This massive infrastructure is ruinously expensive to maintain, which has often led to the owners skimping on vital maintenance, often with disastrous results.

Modern nuclear power plants are vastly more efficient than their predecessors and reprocessing of nuclear fuel means that up to 95% of spent nuclear fuel can be re-used. However, while each generation of nuclear power plant solves some of the problems of its predecessors, it usually creates a few new ones. And problems created by nuclear power plants are very, very costly to fix.

Then there's the issue of terrorism. If terrorists blow up an oil installation, it would be a great tragedy, but the problems the attack caused would be most likely solved within a hundred years. By comparison, a terrorist attack on a nuclear power plant could cause problems that remain long after humans have disappeared from planet Earth.

The fuel that powers nuclear plants is absolutely deadly to humans, especially if fine particles are breathed in. Even spent fuel – that is, fuel that has lost most of its energy – can kill you from one minute's exposure. In theory nuclear fuel is always well shielded in order to protect humans from harm, but as long as there have been nuclear power plants there have been accidents and damage to humans as a result.

Britain has recently announced that it would allow the construction of ten new nuclear plants, apparently without government subsidy. However, critics noted, there is still no long term plan to deal with either the existing or future nuclear waste from Britain's nuclear industry,

As the BBC recently noted: "The cost of cleaning up the UK's ageing nuclear facilities, including some described as 'dangerous', looks set to rise above £73 billion."

The Nuclear Decommissioning Authority, the body in charge of dealing with the UK's radioactive waste, isn't sure how much the final bill is going to be. Jim Morse, a senior director at the authority, told the BBC:

"I think it's a high probability that in the short term [the costs of cleanup] will undoubtedly go up.

"We've still a lot to discover, we haven't started waste retrieval in those parts of the estate where the degradation and radioactive decay has been at its greatest.

When asked if the cost increases could run into billions of pounds, Mr Morse said: "I'm sure it'll be some billions, I really don't know."

"No-one's done this before. It's very difficult to find another measure. There's nothing in engineering terms that allows you to extrapolate from what you have today."

Morse added that the owners of newer nuclear plants would be obliged to clean up their own mess at their own expense. However, it's difficult to imagine the British government being able to avoid paying the bills once more if the owners of a nuclear plant simply walk away or go bankrupt.

Britain's nuclear industry is happy and eager to build new nuclear plants, but is showing little interest in paying to clean up the costs of the previous plants. It is widely believed that Britain's nuclear power industry would refuse to build the new plants if they were held accountable for the downstream costs associated with them. If this is true, the British nuclear industry is going to be reliant on taxpayer handouts for the foreseeable future.

Greenpeace estimates that the ten proposed nuclear plants would only reduce Britain's greenhouse gas emissions by 4%. If Greenpeace is even close to being correct, then the economic rationale for the proposed nuclear plants seems dubious at best.

Assuming that nuclear power plants can be justified on economic grounds, there are other issues that need a close inspection before proceeding. To be happy with a nuclear plant near your home you would have to sincerely believe:

1. That all the major problems with nuclear power plants have now been sorted out.

2. That the corporations who build the plants are being honest with us about the potential hazards.

3. That the governments who regulate the nuclear power industry can be trusted to do their job properly, not just now, but for the next few dozen millennia.

4. That the problems with disposing of nuclear waste have been effectively solved.

The problem with nuclear power stations is that they are generally powered by either uranium-235 or plutonium-239. Even though these fuels last only a few years, their residue will remain toxic for the foreseeable future. For example, the half-life of plutonium, that is, the time it takes for it to lose half its energy, is around 24,000 years, and for uranium-235 the half-life is over 700 million years. It will take another 700 million years to lose half of its remaining energy and another 700 million years to lose half of its remaining energy, and so on. So the waste left behind by nuclear power plants is going to be someone's problem for the next few billion years or so, long after the bunkers built to house it have crumbled into dust.

Also, there is mounting, clear evidence that – in addition to a gradual reduction in the availability of crude oil – uranium, coal and natural gas are also finite resources with a limited life.

A report by the Millennium Project of the World Federation of the United Nations Associations concludes that:

"For nuclear energy to eliminate the greenhouse gas emissions from fossil fuels, about 2000 nuclear power plants would have to be built, at US$5 to 15 billion per plant, over 15 years and possibly an additional 8000 plants beyond that to 2050."

The report adds that there simply isn't enough uranium on the planet to power this many plants.

"Eleven countries have already exhausted their uranium reserves. In total, about 2.3 million tons of uranium have already been produced. At present only one country (Canada) is left having uranium deposits containing uranium with an ore grade of more than 1%, most of the remaining reserves in other countries have ore grades below 0.1% and two thirds of reserves have ore grades below 0.06%. Since [many] stocks will be exhausted within the next 10 years, uranium production capacity must increase by at least some 50% in order to match future demand of current capacity"

The inevitable result of a lessening in supply must be an increase in price, especially as more and more nuclear power stations are built. Increased costs for uranium must inevitably mean increased costs for the electricity produced from the uranium.

Energy wastage

The problem for the West is that the West's economy is based on energy wastage. Therefore, most of the current energy strategies are aimed at continuing this wastage using different technologies, rather than addressing the fundamental reasons for this wastage.

For example, a visitor to a family in Las Vegas observed the wife taking the family washing out of the machine and putting it in the clothes drier.

Las Vegas is in the middle of the desert and it was 35° Celsius outside. The wife could have thrown the whole load of washing out onto a deckchair and it would have been dry in twenty minutes.

There is a deeply ingrained American attitude that says that the reward for all your hard work is the right to squander precious energy: a four-wheel drive Hummer, a fifty room house, air conditioning in every room, a mega-sized clothes drier. If you run your clothes drier in mid-summer, the power company makes more money, the drier manufacturer makes more money, the shop who sold it makes more money, and the housewife can put her feet up and watch her mega-sized flatscreen television.

However, when you have hundreds of millions of people living this way, you end up with the current global energy crisis. What's worsening this global energy crisis is that China and India are now following America's example.

No matter how you juggle the figures, there's simply not enough energy to go around if the American lifestyle becomes a global standard.

However bitter the medicine may be, any solution to the current crisis that's not based around major energy reduction is doomed.

Because most of the world's alternative energy industry is based on quick fixes to the current system, these fixes are frequently coming apart before they even begin. In reality, most of this alternative energy technology either isn't economical, doesn't work, or simply doesn't exist and isn't going to exist in the near future.

It disturbs us to see politicians and business leaders on television promoting fantasy technology using unrealistic economics.

There's no quick fix to either the energy shortage or global warming. In the long term we're all going to have to use less energy, and that means smaller houses, less plastic junk that we don't really need and less wasted trips in our cars.

If we make decisions based on the wrong assumptions, we're just going to make things worse •