The future of energy

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A fundamental change is coming sooner than you might think

SINCE the industrial revolution 200 years ago, mankind has depended on fossil fuel. The notion that this might change is hard to contemplate. Greens may hector. Consciences may nag. The central heating's thermostat may turn down a notch or two. A less thirsty car may sit in the drive. But actually stop using the stuff? Impossible to imagine: surely there isn't a serious alternative?

Such a failure of imagination has been at the heart of the debate about climate change. The green message—use less energy—is not going to solve the problem unless economic growth stops at the same time. If it does not (and it won't), any efficiency saving will soon be eaten up by higher consumption per head. Even the hair-shirt option, then, will bring only short-term relief. And when a dire prophecy from environmentalism's jeremiad looks as if it is coming true, as the price of petroleum rises through the roof and the idea that oil might run out is no longer whispered in corners but openly discussed, there is a temptation to believe that the end of the world is, indeed, nigh.

Not everyone, however, is so pessimistic. For, in the imaginations of a coterie of physicists, biologists and engineers, an alternative world is taking shape. As the special report in this issue describes, plans for the end of the fossil-fuel economy are now being laid and they do not involve much self-flagellation. Instead of bullying and scaring people, the prophets of energy technology are attempting to seduce them. They promise a world where, at one level, things will have changed beyond recognition, but at another will have stayed comfortably the same, and may even have got better.

This time it's serious

Alternative energy sounds like a cop-out. Windmills and solar cells hardly seem like ways of producing enough electricity to power a busy, self-interested world, as furnaces and steam-turbines now do. Battery-powered cars, meanwhile, are slightly comic: more like milk-floats than Maseratis. But the proponents of the new alternatives are serious. Though many are interested in environmental benefits, their main motive is money. They are investing their cash in ideas that they think will make them large amounts more. And for the alternatives to do that, they need to be both as cheap as (or cheaper than) and as easy to use as (or easier than) what they are replacing.

For oil replacements, cheap suddenly looks less of a problem. The biofuels or batteries that will power cars in the alternative future should beat petrol at today's prices. Of course, today's prices are not tomorrow's. The price of oil may fall; but so will the price of biofuels, as innovation improves crops, manufacturing processes and fuels.

Electrical energy, meanwhile, will remain cheaper than petrol energy in almost any foreseeable future, and tomorrow's electric cars will be as easy to fill with juice from a socket as today's are with petrol from a pump. Unlike cars powered by hydrogen fuel cells, of the sort launched by Honda this week, battery cars do not need new pipes to deliver their energy. The existing grid, tweaked and smartened to make better use of its power stations, should be infrastructure enough. What matters is the nature of those power stations.

The price is right

They, too, are more and more likely to be alternative. Wind power is taking on natural gas, which has risen in price in sympathy with oil. Wind is closing in on the price of coal, as well. Solar energy is a few years behind, but the most modern systems already promise wind-like prices. Indeed, both industries are so successful that manufacturers cannot keep up, and supply bottlenecks are forcing prices higher than they otherwise would be. It would help if coal—the cheapest fuel for making electricity—were taxed to pay for the climate-changing effects of the carbon dioxide produced when it burns, but even without such a tax, some ambitious entrepreneurs are already talking of alternatives that are cheaper than coal.

Older, more cynical hands may find this disturbingly familiar. The last time such alternatives were widely discussed was during the early 1970s. Then, too, a spike in the price of oil coincided with a fear that natural limits to supply were close. The newspapers were full of articles on solar power, fusion and converting the economy to run on fuel cells and hydrogen.

Of course, there was no geological shortage of oil, just a politically manipulated one. Nor is there a geological shortage this time round. But that does not matter, for there are two differences between then and now. The first is that this price rise is driven by demand. More energy is needed all round. That gives alternatives a real opening. The second is that 35 years have winnowed the technological wheat from the chaff. Few believe in fusion now, though uranium-powered fission reactors may be coming back into fashion. And, despite Honda's launch, the idea of a hydrogen economy is also fading fast. Thirty-five years of improvements have, however, made wind, solar power and high-tech batteries attractive.

As these alternatives start to roll out in earnest, their rise, optimists hope, will become inexorable. Economies of scale will develop and armies of engineers will tweak them to make them better and cheaper still. Some, indeed, think alternative energy will be the basis of a boom bigger than information technology.

Whether that boom will happen quickly enough to stop the concentration of carbon dioxide in the atmosphere reaching dangerous levels is moot. But without alternative energy sources such a rise is certain. The best thing that rich-world governments can do is to encourage the alternatives by taxing carbon (even knowing that places like China and India will not) and removing subsidies that favour fossil fuels. Competition should do the rest—for the fledgling firms of the alternative-energy industry are in competition with each other as much as they are with the incumbent fossil-fuel companies. Let a hundred flowers bloom. When they have, China, too, may find some it likes the look of. Therein lies the best hope for the energy business, and the planet.

Emissions suspicions

Are countries that regulate greenhouse gases exposing their industries to unfair competition from those that do not?

IN AMERICA they call it the China question. In Europe they call it the America question. In every country that has contemplated regulating greenhouse gases, it is seen as a problem: how can policy ensure that legal limits on emissions do not put local firms at a disadvantage to their foreign competitors? After all, if the cost of compliance puts factories in countries with strict rules out of business, while those in grubbier places flourish, a regulation is worse than useless. The planet's emissions stay the same, or rise, while the country doing its bit for the environment loses investment and jobs.

Politicians have been quick to spot this threat. Back in 1997 America's Senate voted by 95-0 to reject any international treaty on climate change that did not embrace industrial rivals such as China. A bill to limit emissions that came close to passing the Senate earlier this month included fearsome “carbon tariffs” on imports from such countries, to help shelter American factories from unfair competition. But warnings from manufacturers that the bill would still cost millions of jobs helped to ensure its defeat. The European Union has already adopted an emissions cap, but France's president, Nicolas Sarkozy, wants it to build in a “carbon tariff” too.

How grave is the danger that these tariffs would counter? By a variety of methods, economists are trying to assess which industries are most at risk, how much they would suffer under different climate regimes and how best to respond. Their findings do not support the shrill protectionist rhetoric.

Lost in the hot air

The authors of “Leveling the Carbon Playing Field”, published recently by the Peterson Institute for International Economics, a think-tank based in Washington, DC, argue that the damage would be small. Most manufacturers (let alone service industries) do not use much energy, the main source of emissions, and so would not suffer big costs. Energy makes up less than 1% of the cost of making cars, furniture or computers. Even some energy-intensive industries, such as power generation, should not be much affected. Since they have no foreign competition, they could pass on extra costs to their customers.

Only a few industries—metals, paper, chemicals, cement and the like—are both global and profligate enough to be at risk. These accounted for just over 3% of America's output in 2005 and less than 2% of its jobs. Much the same is true in Europe: those industries, plus refining, account for less than 5% of output and an even smaller share of jobs, according to the interim report* of a group of academics studying the effects of Europe's carbon-trading scheme.

Even those supposedly vulnerable industries do not seem to have wilted in the face of a carbon price, according to two contributors to the study, Richard Baron and Julia Reinaud of the International Energy Agency, a Paris-based consultancy-cum-watchdog for energy-consuming nations. Ms Reinaud cannot even detect any impact on aluminium, which is as energy-intensive and widely traded as any good. She points out that a shuttered smelter in Germany reopened in 2007, despite the rising cost of emissions.

There are many explanations for this resilience. One is that booming demand for aluminium and other commodities has kept all manufacturers profitable. Product specifications that vary from country to country, meanwhile, help to protect refiners from foreign competition. And Europe has handed out so many free permits to pollute that the costs of meeting its emissions cap have been negligible so far.

But putting a price on carbon may still do some harm in the future, Ms Reinaud cautions. Europe is planning a tighter cap and fewer free permits. Many blueprints for emissions-trading in America call for no free allocations whatsoever. What is more, the biggest effects may come not in the short term, as factory closures, but later, as lower investment in new plant.

A study sponsored by Resources for the Future, an American think-tank, has tried to describe how American industry would meet a carbon price, albeit one of just $10 a ton—much less than the European price of over €25 ($39). Based on economic modelling, it concludes that industrial output would fall by less than 1%. The hardest-hit industry would be metals, but even that would shrink by only 1.5%. Better yet, the damage could be offset by granting energy-intensive firms enough free permits to cover just 15% of their emissions.

Another study under way at the Pew Centre on Global Climate Change, another think-tank, sizes up a $15 carbon price using data on the past effects of rising energy prices on industry. It concludes that output would fall by 2% or less in 80% of cases. Paper and glass would face a bigger contraction, of 5%. Still, even the most vulnerable industries would not suffer the Armageddon that lobbying groups are predicting.

That is important, since it suggests that the politicians are over-reacting, and that their remedies may actually make matters worse. A carbon tariff, for example, would be hard to implement. Customs officials would either have to assess the emissions embedded in imports, an impossibly complicated task, or make arbitrary assumptions, a recipe for a trade war. Moreover, it would do nothing to protect exports of energy-intensive goods from cheap competition.

Many studies also point out that carbon caps could bring benefits, in the form of factories making windmills, say, or solar panels. But these are even harder to quantify than the costs—and so they are even easier for the politicians to ignore.

*"The European Carbon Market in Action: Lessons from the First Trading Period. Interim Report."

The power and the glory

The next technology boom may well be based on alternative energy, says Geoffrey Carr. But which sort to back?

EVERYONE loves a booming market, and most booms happen on the back of technological change. The world's venture capitalists, having fed on the computing boom of the 1980s, the internet boom of the 1990s and the biotech and nanotech boomlets of the early 2000s, are now looking around for the next one. They think they have found it: energy.

Many past booms have been energy-fed: coal-fired steam power, oil-fired internal-combustion engines, the rise of electricity, even the mass tourism of the jet era. But the past few decades have been quiet on that front. Coal has been cheap. Natural gas has been cheap. The 1970s aside, oil has been cheap. The one real novelty, nuclear power, went spectacularly off the rails. The pressure to innovate has been minimal.

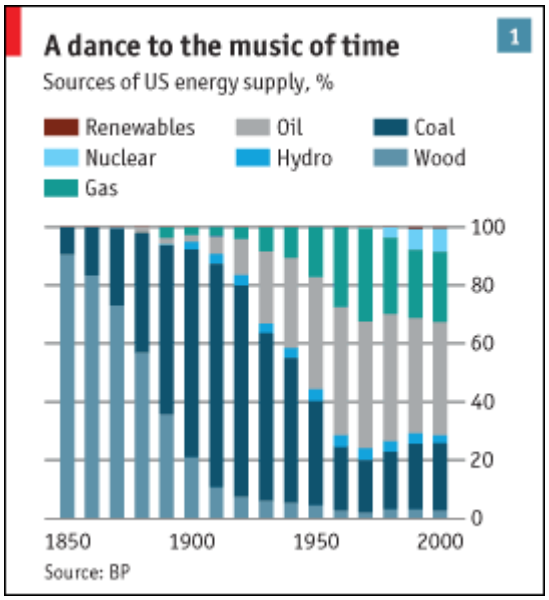
In the space of a couple of years, all that has changed. Oil is no longer cheap; indeed, it has never been more expensive. Moreover, there is growing concern that the supply of oil may soon peak as consumption continues to grow, known supplies run out and new reserves become harder to find.

The idea of growing what you put in the tank of your car, rather than sucking it out of a hole in the ground, no longer looks like economic madness. Nor does the idea of throwing away the tank and plugging your car into an electric socket instead. Much of the world's oil is in the hands of governments who have little sympathy with the rich West. When a former head of America's Central Intelligence Agency allies himself with tree-hugging greens that his outfit would once have suspected of subversion, you know something is up. Yet that is one tack James Woolsey is trying in order to reduce his country's dependence on imported oil.

The price of natural gas, too, has risen in sympathy with oil. That is putting up the cost of electricity. Wind- and solar-powered alternatives no longer look so costly by comparison. It is true that coal remains cheap, and is the favoured fuel for power stations in industrialising Asia. But the rich world sees things differently.

In theory, there is a long queue of coal-fired power stations waiting to be built in America. But few have been completed in the past 15 years and many in that queue have been put on hold or withdrawn, for two reasons. First, Americans have become intolerant of large, polluting industrial plants on their doorsteps. Second, American power companies are fearful that they will soon have to pay for one particular pollutant, carbon dioxide, as is starting to happen in other parts of the rich world. Having invested heavily in gas-fired stations, only to find themselves locked into an increasingly expensive fuel, they do not want to make another mistake.

That has opened up a capacity gap and an opportunity for wind and sunlight. The future price of these resources—zero—is known. That certainty has economic value as a hedge, even if the capital cost of wind and solar power stations is, at the moment, higher than that of coal-fired ones.



The reasons for the boom, then, are tangled, and the way they are perceived may change. Global warming, a long-range phenomenon, may not be uppermost in people's minds during an economic downturn. High fuel prices may fall as new sources of supply are exploited to fill rising demand from Asia. Security of supply may improve if hostile governments are replaced by friendly ones and sources become more diversified. But none of the reasons is likely to go away entirely.

Global warming certainly will not. "Peak oil", if oil means the traditional sort that comes cheaply out of holes in the ground, probably will arrive soon. There is oil aplenty of other sorts (tar sands, liquefied coal and so on), so the stuff is unlikely to run out for a long time yet. But it will get more expensive to produce, putting a floor on the price that is way above today's. And political risk will always be there—particularly for oil, which is so often associated with bad government for the simple reason that its very presence causes bad government in states that do not have strong institutions to curb their politicians.

A prize beyond the dreams of avarice

The market for energy is huge. At present, the world's population consumes about 15 terawatts of power. (A terawatt is 1,000 gigawatts, and a gigawatt is the capacity of the largest sort of coal-fired power station.) That translates into a business worth $6 trillion a year—about a tenth of the world's economic output—according to John Doerr, a venture capitalist who is heavily involved in the industry. And by 2050, power consumption is likely to have risen to 30 terawatts.

Scale is one of the important differences between the coming energy boom, if it materialises, and its recent predecessors—particularly those that relied on information technology, a market measured in mere hundreds of billions. Another difference is that new information technologies tend to be disruptive, forcing the replacement of existing equipment, whereas, say, building wind farms does not force the closure of coal-fired power stations.

For both of these reasons, any transition from an economy based on fossil fuels to one based on renewable, alternative, green energy—call it what you will—is likely to be slow, as similar changes have been in the past (see chart 1). On the other hand, the scale of the market provides opportunities for alternatives to prove themselves at the margin and then move into the mainstream, as is happening with wind power at the moment. And some energy technologies do have the potential to be disruptive. Plug-in cars, for example, could be fuelled with electricity at a price equivalent to 25 cents a litre of petrol. That could shake up the oil, carmaking and electricity industries all in one go.

The innovation lull of the past few decades also provides opportunities for technological leapfrogging. Indeed, it may be that the field of energy gives the not-quite-booms in biotechnology and nanotechnology the industrial applications they need to grow really big, and that the three aspiring booms will thus merge into one.

The possibility of thus recapturing the good times of their youth has brought many well-known members of the "technorati" out of their homes in places like Woodside, California. Energy has become supercool. Elon

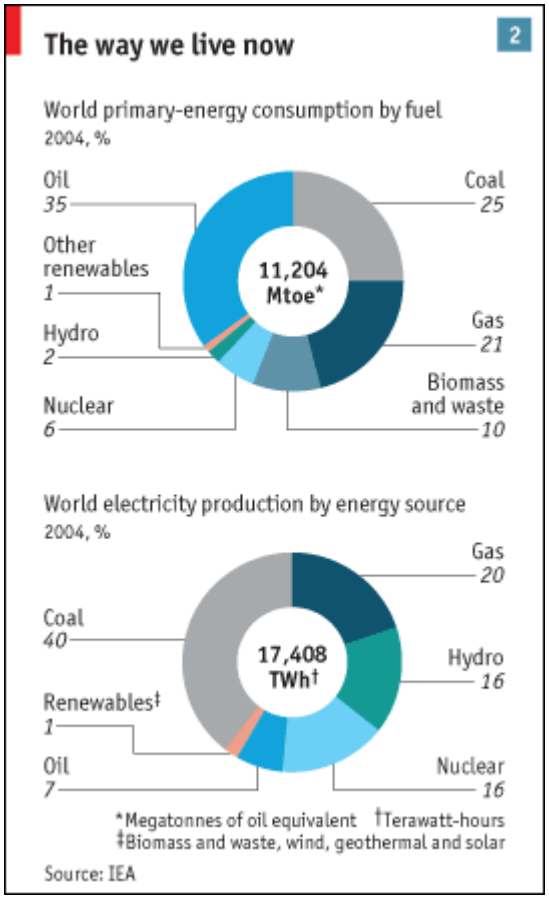
Musk, who co-founded PayPal, has developed a battery-powered sports car. Larry Page and Sergey Brin, the founders of Google, have started an outfit called Google.org that is searching for a way to make renewable energy truly cheaper than coal (or RE<C, as they describe it to their fellow geeks).

Vinod Khosla, one of the founders of Sun Microsystems, is turning his considerable skills as a venture capitalist towards renewable energy, as are Robert Metcalfe, who invented the ethernet system used to connect computers together in local networks, and Mr Doerr, who works at Kleiner Perkins Caufield & Byers, one of Silicon Valley's best-known venture-capital firms. Sir Richard Branson, too, is getting in on the act with his Virgin Green Fund.

This renewed interest in energy is bringing forth a raft of ideas, some bright, some batty, that is indeed reminiscent of the dotcom boom. As happened in that boom, most of these ideas will come to naught. But there could just be a PayPal or a Google or a Sun among them.

More traditional companies are also taking an interest. General Electric (GE), a large American engineering firm, already has a thriving wind-turbine business and is gearing up its solar-energy business. The energy researchers at its laboratories in Schenectady, New York, enjoy much of the intellectual freedom associated with start-up firms, combined with a secure supply of money.

Meanwhile, BP and Shell, two of the world's biggest oil companies, are sponsoring both academic researchers and new, small firms with bright ideas, as is DuPont, one of the biggest chemical companies. Not everyone has joined in. Exxon Mobil, the world's largest oil company not in government hands, is conspicuously absent. But in many boardrooms renewables are no longer seen as just a way of keeping environmentalists off companies' backs.



Some people complain that many existing forms of renewable energy rely on subsidies or other forms of special treatment for their viability. On the surface, that is true. Look beneath, though, and the whole energy sector is riddled with subsidies, both explicit and hidden, and costs that are not properly accounted for. Drawing on the work of people like Boyden Gray, a former White House counsel, Mr Woolsey estimates that American oil companies receive preferential treatment from their government worth more than $250 billion a year. And the Intergovernmental Panel on Climate Change (IPCC), a United Nations-appointed group of scientific experts, reckons that fossil fuels should carry a tax of $20-50 for every tonne of carbon dioxide they generate in order to pay for the environmental effects of burning them (hence the fears of the power-generators).

So the subsidies and mandates offered to renewable sources of power such as wind turbines often just level the playing field. It is true that some subsidies amount to unwarranted market-rigging: examples include those handed by cloudy Germany to its solar-power industry and by America to its maize-based ethanol farmers when Brazilian sugar-based ethanol is far cheaper. Others, though, such as a requirement that a certain proportion of electricity be derived from non-fossil-fuel sources, make no attempt to pick particular technological winners. They merely act to stimulate innovation by guaranteeing a market to things that actually work.

If the world were rational, all of these measures would be swept away and replaced by a proper tax on carbon—as is starting to happen in Europe, where the price arrived at by the cap-and-trade system being introduced is close to the IPCC's recommendation. If that occurred, wind-based electricity would already be competitive with fossil fuels and others would be coming close. Failing that, special treatment for alternatives is probably the least bad option—though such measures need to be crafted in ways that favour neither incumbents nor particular ways of doing things, and need to be withdrawn when they are no longer necessary.

The poor world turns greener too

That, at least, is the view from the rich world. But poorer, rapidly developing countries are also taking more of an interest in renewable energy sources, despite assertions to the contrary by some Western politicians and businessmen. It is true that China is building coal-fired power stations at a blazing rate. But it also has a

large wind-generation capacity, which is expected to grow by two-thirds this year, and is the world's second-largest manufacturer of solar panels—not to mention having the largest number of solar-heated rooftop hot-water systems in its buildings.

Brazil, meanwhile, has the world's second-largest (just behind America) and most economically honest biofuel industry, which already provides 40% of the fuel consumed by its cars and should soon supply 15% of its electricity, too (through the burning of sugarcane waste). South Africa is leading the effort to develop a new class of safe and simple nuclear reactor—not renewable energy in the strict sense, but carbon-free and thus increasingly welcome. These countries, and others like them, are prepared to look beyond fossil fuels. They will get their energy where they can. So if renewables and other alternatives can compete on cost, the poor and the rich world alike will adopt them.

That, however, requires innovation. Such innovation is most likely to come out of the laboratories of rich countries. At a recent debate at Columbia University, which *The Economist* helped to organise, Mr Khosla defended the proposition, "The United States will solve the climate-change problem". The Californian venture capitalist argued that if cheaper alternatives to fossil fuels are developed, simple economics will ensure their adoption throughout the world. He also insisted that the innovation which will create those alternatives will come almost entirely out of America.

As it happens, he lost. But that does not mean he is wrong. There are lots of terawatts to play for and lots of money to be made. And if the planet happens to be saved on the way, that is all to the good.

Double, double, oil and trouble

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Is it "peak oil" or a speculative bubble? Neither, really

AFTER oil hit its recent record of $135 a barrel, consumers and politicians started to lash out in every direction. Fishermen in France have been blockading ports and pouring oil on the roads in protest. British lorry drivers have paraded coffins through London as a token of the imminent demise of the haulage industry. In response, Gordon Brown, Britain's prime minister, is badgering oil bosses to increase production from the North Sea, while Nicolas Sarkozy, the president of France, wants the European Union to suspend taxes on fuel.

In America, too, politicians are haranguing oil bosses and calling for tax cuts. Congress has approved a bill to prevent the government from adding to America's strategic stocks of oil, and is contemplating another to enable American prosecutors to sue the governments of the Organisation of the Petroleum Exporting Countries (OPEC) for market manipulation.

But the most popular scapegoats are "speculators" of the more traditional sort. OPEC itself routinely blames them for high prices. The government of India is so sure that speculation makes commodities dearer that it has banned the trading of futures contracts for some of them (although not oil). Germany's Social Democratic Party proposes an international ban on borrowing to buy oil futures, on the same grounds. Joe Lieberman, chairman of the Senate's Homeland Security Committee, is also mulling regulation of some sort, having concluded that "speculators are responsible for a big part of the commodity price increases". The assumption underlying such ideas is that a bubble is forming, and that if it were popped, the price of oil would be much lower.

Others assume the reverse: that the price is bound to keep rising indefinitely, since supplies of oil are running short. The majority of the world's crude, according to believers in "peak oil", has been discovered and is already being exploited. At any rate, the size of new fields is diminishing. So production will soon reach a pinnacle, if it has not done so already, and then quickly decline, no matter what governments do.

As different as these theories are, they share a conviction that something has gone badly wrong with the market for oil. High prices are seen as proof of some sort of breakdown. Yet the evidence suggests that, to the contrary, the rising price is beginning to curb demand and increase supply, just as the textbooks say it should.

Stocks, bonds and barrels

Those who see speculators as the culprits point to the emergence of oil and other commodities as a popular asset class, alongside stocks, bonds and property. Ever more investors are piling into the oil markets, the argument runs, pushing up the price as they do so. The number of transactions involving oil futures on the

New York Mercantile Exchange (NYMEX), the biggest market for oil, has almost tripled since 2004. That neatly mirrors a tripling of the price of oil over the same period.

But Jeffrey Harris, the chief economist of the Commodity Futures Trading Commission (CFTC), which regulates NYMEX and other American commodities exchanges, does not see any evidence that the growth of speculation in oil has caused the price to rise. Rising prices, after all, might have been stimulating the growing investment, rather than the other way around. There is no clear correlation between increased speculation and higher prices in commodities markets in general. Despite a continuing flow of investment in nickel, for example, its price has fallen by half over the past year.

By the same token, the prices of several commodities that are not traded on any exchange, and are therefore much harder for speculators to invest in, have risen even faster than that of oil. Deutsche Bank calculates that cadmium, a rare metal, has appreciated twice as much as oil since 2001, for example, and the price of rice has risen fractionally more.

Investment can flood into the oil market without driving up prices because speculators are not buying any actual crude. Instead, they buy contracts for future delivery. When those contracts mature, they either settle them with a cash payment or sell them on to genuine consumers. Either way, no oil is hoarded or somehow kept off the market. The contracts are really a bet about which way the price will go and the number of bets does not affect the amount of oil available. As Mr Harris puts it, there is no limit to the number of “paper barrels” that can be bought and sold.

That makes it harder for a bubble to develop in oil than in the shares of internet firms, say, or in housing, where the supply of the asset is finite. Ultimately, says David Kirsch of PFC Energy, a consultancy, there is only one type of customer for crude: refineries. If speculators on the futures markets get carried away, pushing prices so high that refineries run at a loss, they will simply shut down, causing the price to fall again. Moreover, speculators do not always assume that prices will rise. As recently as last year, the speculative bears on NYMEX outweighed the bulls.

There is, admittedly, a growing category of inherently bullish investment funds that seek to track commodity-price indices, in which oil is usually the biggest component. Politicians have begun to denounce these “index funds”, since they make money for their investors only if prices rise. According to Mr Lieberman, they have grown in value from $13 billion to $260 billion over the past five years. This surge of investors betting on rising prices, many observers contend, has become a self-fulfilling prophecy, helping to push prices ever higher and thus attract yet more investment.

But Bob Greer, of PIMCO, an asset-management firm, argues that even index funds make unlikely suspects. For one thing, they too invest in futures, rather than in physical supplies of oil. So every month, they must trade contracts that are about to fall due for ones that will not mature for several months. That makes them big sellers of oil for prompt delivery.

What is more, their growth is not as impressive as it first appears. Paul Horsnell of Barclays Capital, an investment bank, puts the total value of index funds and other similar investments at $225 billion. That is less than half the market capitalisation of Exxon Mobil, he points out, and a tiny fraction of the $50 trillion-odd of transactions in the oil markets each year. Although index funds have grown quickly, that growth stems in large part from the rise in value of the futures they hold, rather than from fresh investment flows. He estimates that index funds swelled by $13 billion in the first quarter of this year, for example, of which all but $2 billion derives from the rise in commodity prices.

Back to basics

Mr Harris of the CFTC, for one, believes that the oil price is still a function of supply and demand. For the past few years, the world's production capacity has grown only sluggishly. Meanwhile, demand, especially from the developing world, has been growing faster. So there is hardly any slack in the system. Only Saudi Arabia and the United Arab Emirates are thought to be able to increase their output from today's levels, and even then, there are doubts, since Saudi Arabia, in particular, is secretive about the state of its oil industry.

That leaves the oil market at the mercy of even small disruptions to supply. Prices tend to jump each time militants sabotage an oil pipeline in Nigeria, bad weather threatens production in the Gulf of Mexico, or political clouds gather over the Persian Gulf.

The problem is exacerbated by a growing mismatch between the type of oil being produced and the refineries that must process it. The most common benchmark prices, including the one used in this article, refer to “light” crude, the least viscous sort, which produces the most petrol and diesel when refined. “Heavy” oil, by contrast, yields more fuel oil, which is used mainly for heating.

At the moment, diesel is in short supply and there is a glut of fuel oil. That makes processing heavy oil unprofitable for some refineries, since the gains from diesel are outweighed by losses on fuel oil. As refineries turn instead to lighter grades, it pushes their prices yet higher. The discount on heavier crudes has

risen to record levels. But even then, points out Ed Morse, of Lehman Brothers, another investment bank, Iran is having trouble selling the stuff. It is storing huge quantities of unsold oil on tankers moored off its coast.

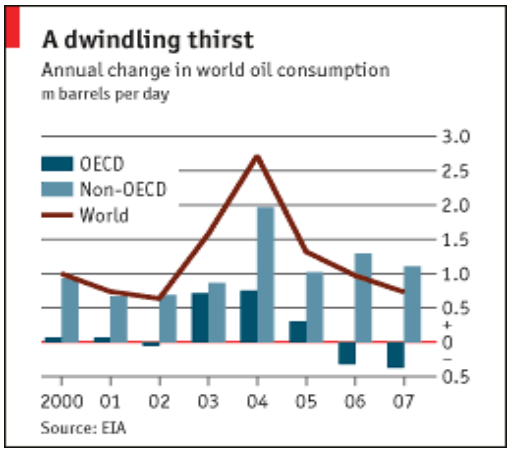
Presumably, Iran and other heavy-oil producers will eventually be obliged to drop prices far enough to make processing the stuff worth refiners' while. In the longer run, more refineries will invest in the equipment needed to crack more diesel out of heavy oil. Both steps will, in effect, increase the world's oil supply, and so help to ease prices.

But improving an existing refinery or building a new one is a slow and capital-intensive business. Firms tend to be very conservative in their investments, since refineries have decades-long life-spans, during which prices and profits can fluctuate wildly. It can also be difficult to find a site and obtain the right permits—one of the reasons why no new refineries have been built in America for over 30 years. Worse, new kit is becoming ever more expensive. Cambridge Energy Research Associates (CERA), a consultancy, calculates that capital costs for refineries and petrochemical plants have risen by 76% since 2000.

Much the same applies to the development of new oilfields. CERA reckons that the cost of developing them has risen even faster—by 110%. At the same time, oilmen remain scarred by the rapid expansion of output in the late 1970s, in response to previous spikes in prices, that led to a glut and so to a prolonged slump. Exxon Mobil claims that it still assesses the profitability of potential investments using the same assumptions about the long-term oil price as it did at the beginning of the decade, for fear that prices might tumble again. Environmental concerns are also an obstacle: America, for one, has banned oil production off most of its coastline.

Increasing nationalism on the part of oil-rich countries is adding to the difficulties. Geologists are convinced that there is still a lot of oil to be discovered in the Middle East and the former Soviet Union, but governments in both regions are reluctant to give outsiders access. Elsewhere, the most promising areas for exploration are also the most technically challenging: in deep water, or in the Arctic, or both. Although there have been big recent discoveries in such places, they will take longer to develop, and costs will be higher. The most expensive projects of all involve the extraction of oil from bitumen, shale and even coal, through elaborate processing. The potential for these is more or less unlimited, although analysts put the costs as high as $70 a barrel—more than the oil price this time last year.

Nonetheless, PFC Energy has examined projects that are already under way, and concluded that global oil production will grow by over 3m barrels a day (b/d) over the course of this year and next. In particular, it expects production outside OPEC to grow by about 500,000 b/d both years—a marked increase from the near stagnation of recent years.



Meanwhile, the high price is clearly beginning to crimp demand. The growth in global consumption last year was barely a quarter what it was in 2004 (see chart); this year, it is likely be even lower. In rich countries (or at least among the members of the Organisation for Economic Co-operation and Development (OECD), a rough proxy), the effect is even more pronounced. Consumption has been falling for the past two and a half years.

Poorer countries' demand for oil is still rising, albeit at a slowing pace. That is partly because their economies are growing faster, and partly because their consumers are shielded from the rising price through subsidies. But the increasing expense of such measures is forcing governments to water them down or scrap them altogether (see article). That, in turn, should further sap consumption.

Oil pique

China's growing thirst for oil is often put forward as one of the main factors behind today's higher oil prices. Demand for diesel there, for example, rose by over 9% in the year to April. But Mr Morse argues that such growth might not last. The government has ordered oil firms to increase their stocks of fuel by 50% to be sure there are no embarrassing shortages during the Olympics. It is also planning to run some power plants near Beijing on diesel rather than coal, in an attempt to reduce pollution during the games. These measures are helping to boost China's demand for diesel, but the effect will be transitory.

In the short run, neither demand for nor supply of oil is very elastic. It takes time for people to replace their old guzzlers with more fuel-efficient cars, or to switch to jobs with shorter commutes, or to move closer to public transport. By the same token, it can take ten years or more to develop an oilfield after its discovery—and that does not include the time firms need to bolster their exploration units.

Gary Becker, an economist at the University of Chicago, has calculated that in the past, over periods of less than five years, oil consumption in the OECD dropped by only 2-9% when the price doubled. Likewise, oil production in countries outside OPEC grew by only 4% every time the price doubled. But over longer periods, consumption dropped by 60% and supply rose by 35%. The precise numbers may be slightly different this time round, but the pattern will be the same.