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## The power and the glory

~~A survey of The future of energy~~  
**The next technology boom may well be based on alternative energy, says Geoffrey Carr (interviewed here). But which sort to back?**

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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.

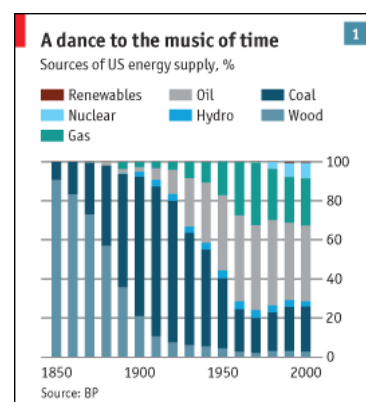
Global warming certainly will not. "Peak oil", if oil means the traditional sort that comes cheaply out of holes in the ground, probably will arrive soon. There is oil aplenty of other sorts (tar sands, liquefied coal and so on), so the stuff is unlikely to run out for a long time yet. But it will get 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](http://google.org/) (<http://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.

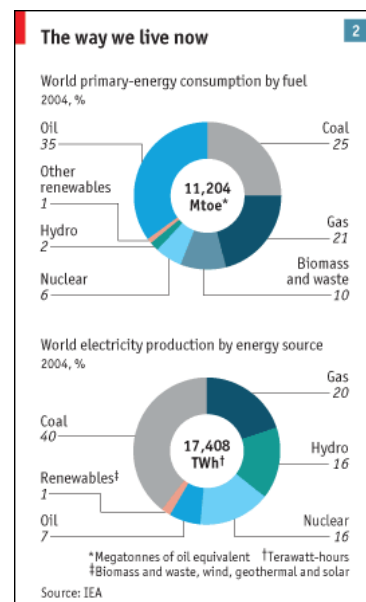
More traditional companies are also taking an interest. General Electric (GE), a large American engineering firm, already has a thriving wind-turbine business and is gearing up its solar-energy business. The energy researchers at its laboratories in Schenectady, New York, enjoy much of the intellectual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

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