



Carbon Commentary Newsletter #8

A critical appraisal of issues in the move to a low-carbon economy

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Nuclear is back. At least eleven companies want to build nuclear power stations in the UK. The only nuclear reactor in construction in Europe is now well behind schedule. What has been the experience of the nuclear giant Areva as it tries to construct a new power station? At the other end of the spectrum, this edition of Carbon Commentary looks at the impact of the Code for Sustainable Homes on the property industry. Some very good looking new houses are beginning to be built, but they aren't cheap. Other articles look at the carbon footprint confessions of Patagonia clothing, the relevance of the new Kingsnorth power station to carbon capture, the possibility of using grass as the raw material for biofuels, and disturbing new evidence of the impact of temperature rises on the takeup of carbon dioxide in autumn.

A handwritten signature in cursive script that reads "Chris Goodall". The ink is dark and the handwriting is fluid and personal.

Chris Goodall

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Chris Goodall's book *How to Live a Low-Carbon Life* won the September 2007 Clarion prize for non-fiction.

Zero-carbon homes may look nice but they aren't cheap

Carbon Commentary has visited two sites to look at the costs of building houses under the new rules (not yet mandatory) established by the Code for Sustainable Homes (CSH). By 2016, all new UK homes will have to have no net carbon emissions ('Level 6') and the implications for construction techniques are profound. Today, most homes are built to about Level 1, or possibly 2. To get to Level 6 will require huge changes in how houses are built, heated, and ventilated. And they will need expensive renewable energy technologies built into the home as well.

At Wimpey's 145-home development in Milton Keynes, construction costs of houses at Level 3 are running at '100-110%' more than standard. The self-build company Potton is offering a Level 6 design (one of the first in the UK) for an even more expensive £180 a square foot, up from about £75 for a standard Level 3 model. This takes the construction cost of a standard 1,000 sq ft (92 sq metre) home up from £75,000 to £180,000. Much of the increment comes from the need to install large amounts of renewable electricity generation. Some of the cost premium over today's badly insulated homes will eventually erode as builders get better at building air-tight houses. But we shouldn't be in any doubt about the huge implications of the CSH for builders, landowners, and buyers.



The Lighthouse by Potton

Every few weeks, Potton holds crowded seminars at its demonstration Code 6 house at the Building Research Establishment near Watford, just north of London. Potton is proud of its elegant design, shaped like a spinnaker in wind. The seminar leader talks with obvious emotion about the huge changes that are about to hit UK housebuilding.

Having lagged the rest of northern Europe for half a century, the UK will have the toughest building regulations in the world by 2016. This astonishing turnabout divides the construction industry into two. The more conservative elements in this most old-fashioned of industries are quietly and not-so-quietly saying that the rules will be impossible to meet and calling for a concerted campaign to persuade the government to relax the Code.

The rest of the industry is intrigued by the challenge, clearly hoping that the Code will finally erode the reliance on the UK's standard brick and block construction. It will be difficult to achieve the insulation targets using old methods and, at long last, builders will be forced to erect pre-fabricated timber and steel frames houses with infinitely better standards and finish. There's no question about which side of the fence Potton sits on. As a subsidiary of the Irish modular buildings group Kingspan, Potton is an unashamed modernist, proud of designing the first Level 6 single family home.

The Lighthouse is an extraordinary building. Elegant and graceful from the outside, it is covered in sweet chestnut cladding. Inside, it is a mixture of beauty and function. The bottom floor is small and undistinguished, with the two quite small bedrooms sharing the space with a drying area and a large wood-pellet burner.

Upstairs is hugely attractive. Light and airy rooms with high ceilings are uplifting to the spirit. This is a small house by most people's standards but the simplicity of the design gives it grace and style. An effective heat recovery system collects the warm stale air at the top of the house and uses it to heat the incoming colder fresh air. The quality of the triple-glazed windows means that even on a dull January day one barely needs to turn the lights on.

Broadly speaking, a very well insulated and air-tight house will get the builder to Level 4 of the CSH, a level that will have to be reached within a few years. Level 6 is going to be obligatory by 2016, only eight years away. It's important to note that the steepness of the demands the CSH places on builders increases as time goes on. Level 6 is the Everest of construction standards. It requires the builder to measure the total prospective energy use of the building, including the electricity for appliances and lighting as well as heating, and then completely offset this by renewable energy technologies installed on or near the house.

How does the Lighthouse reach net carbon neutrality and achieve Level 6? Not only does the house have to have the highest insulation and air tightness standards, but it has a huge expanse of solar photovoltaic panels on the roof

Here are the details of expected energy demand for the building:

Energy use	Kilowatt hours (kWh) per year	Comment
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ELECTRICITY		
Lighting	500	Average UK house about 750. The Lighthouse number looks high as it only has energy efficient bulbs. 300 might be a better estimate
Ventilation and heat recovery equipment	200	Not used in conventional houses
Other fans and heat distribution equipment	400	All houses need hot water pumps and the like. This is a bit higher than the typical home
Catering	900	The house has no gas, so all cooking is via electricity. This number looks very low for a family that cooks often at home
Appliances	2,100	This looks high for a house of this size
TOTAL ELECTRICITY	4,100	About 10% more than a typical UK house of this size
GAS		
Domestic hot water	3,000	Solar thermal panels on the roof reduce this from about 4,000 in the typical house
Space heating	1,700	Typical conventional house of this size has a demand of about 14,000 kWh
TOTAL GAS	4,700	Typical house has total gas demand of 19,000 kWh
ELECTRICITY PLUS GAS	8,800	Nearer 24,000 for typical house

As might be expected, the Lighthouse shows huge reductions in gas demand. The high-quality insulation reduces total heating need from 19,000 kWh to 1,700 kWh – a cut of 90%. This heating demand, and the hot water need of 3,000 kWh, are met by a wood-burning stove burning pelleted wood. In the summer, the hot water use is covered by a solar hot water system. Total heating demand will be met by not much more than half a tonne of dry wood a year – equivalent to about a full load of logs in a farmers' pick-up van.

Because heating demand is provided by wood, there is no carbon consequence. And Potton estimate that the cost of this wood is about £30 a year (perhaps a little optimistically). This is the complete fuel bill for the house. At current prices, an average house of this size might have gas and electricity costs of about £1,000 a year.

On the other hand, total electricity demand is slightly higher than the UK average. This is partly because the 'air conditioning' system – heating incoming air with the heat from the stale outgoing air – needs fans and pumps to power it. And, second, all cooking is done with electricity. (Most UK houses use gas for at least some cooking.) The heating may be carbon neutral because of the wood fire, but grid electricity has to be used. A Level 6 house has to incorporate on-site renewables to cover the complete 4,100 kWh used for appliances, lighting, fans, and pumps.

The Lighthouse uses solar photovoltaic panels to 'offset' the electricity need. The economics are, as might be expected, quite shocking. The makers of the Lighthouse have calculated that 4,100 kWh requires the house to have 4.7 kW of solar panels. By 4.7 kW, I am referring to the figure for the total maximum generation from the panel array at noon on a June day. Typically, we can assume that 1 kW of panels generates about 1,000 kWh a year in the English Midlands. So Lighthouse is being a bit generous with its solar panels – it might have been possible to get away with 4.1 kW, or even 3.5 kW on the English south coast. An installation that costs 4.7 kW will cost at least £25,000 (partly because the ridiculously generous German feed-in tariffs are pushing up global demand for solar panels). So using solar panels to avoid an electricity bill of £400 a year (and making the house 'carbon neutral') is adding £25,000 to the cost of the house. Working out the full economics of solar electricity in the home is complex

but the net return on the investment of £25k is no more than about 5%.

The people attending the Lighthouse seminar liked the idea of carbon neutrality and selling electrons back to the national power network. But the cost of this is enormous – if the panels last 25 years it is may be as much as £600 per tonne of carbon dioxide. When CO2 is trading on the exchanges at about £17 per tonne, it is really unclear why the government is telling us that home generation is the best solution to climate change. Roof-mounted solar PV is, in effect, a requirement if we want to get to Level 6, but is adding 15% to the cost of a house. If, instead, the government allowed housebuilders to invest in local commercial-scale wind farms instead, carbon neutrality might cost as little as a few hundred pounds.

To summarise, let's look again briefly at the cost of building homes under the CSH, as calculated by Potton, makers of the Lighthouse:

Level 3 house of 1,000 sq ft	£75,000
Level 4 house of 1,000 sq ft	£130,000
Cost of solar panels (PV for electricity)	£25,000
Cost of solar hot water	£3,000
Cost of wood-burning boiler	£5,000
Total incremental cost of renewables	£33,000
Other costs to get from Level 4 to Level 6	£17,000
Level 6 house of 1,000 sq ft	£180,000

Wimpey Homes

At Oxley Wood on the outskirts of Milton Keynes, Wimpey Homes is developing a large estate of genuinely modern homes. These aren't conventional houses covered with a layer of eco-bling, they use proper north European construction techniques to provide good levels of insulation and real air-tightness.



Wimpey Homes in Milton Keynes

Oxley Wood is being built with the future in mind. Managers at Wimpey are visibly worried about the cost of the houses. It's clearly been an extraordinary surprise to see just how difficult and expensive house construction can be. These are people who knew exactly how to put up a brick and block house on a tight schedule and on budget. But today, time after time, they refer to the huge investment they are making at this site, while reassuring us that they believe that the lessons they are learning here are going to help them on future projects. 'We could have just sat and watched,' someone said, 'but we decided it would be cheaper in the end if we grasped the problems posed by the

demands of the Code.'

Sales are going reasonably well. 34 homes have been sold and the levels of interest are high. Some of the viewers go away hating the estate – it is totally different in appearance to a conventional new development. And Wimpey people have also found that real eco-nuts have left disappointed. 'Call this an eco-house,' said one disgruntled viewer, 'it doesn't even have composting toilets.'

Wimpey is keen to say that so far the purchasers are largely well-educated professionals. They like the modern feel and the effort Wimpey has put in to ensure that the layout has the feel of a close-knit community. The roads will look like Dutch or German 'Homezones' enabling pedestrians and cyclists to use the streets safely.

Some potential buyers have been worried about the resale values of the houses. Homes that look this different are difficult to value. Local mortgage companies have not been falling over themselves to offer to lend on the estate. Wimpey says it is only achieving prices in line with local conditions – about £220 per square foot – and there isn't even a small premium to reflect the lower utility bills that the houses will have.

Here's the crunch. Wimpey gets £220 per square foot for its Level 3 houses. The Level 6 Potton Lighthouse costs £180 per square foot to build (and the self-builder is putting in his work for free). Where is the margin for the builder, and the money to pay for the land? Unless costs change dramatically, the arrival of the Level 6 requirement is going to disrupt the balance between land prices, builder profits, and final prices. My sense is that the most vulnerable element is land values. The painful drive to Level 6 is going to oblige builders to pay less for their land. At a time when the mass market housebuilders are already quietly liquidating small portions of their land banks, the downward pressure on the price of development sites is going to continue.

Nuclear power: the new generation



The new Finnish nuclear reactor at Olkiluoto (OLK3)

Nuclear power may or may not be an unfortunate necessity. But a look at Finland should temper any optimism about construction costs.

The government's decision in early January 2007 to support (or, more precisely, not oppose) the construction of nuclear power plants in the UK prompted strongly felt responses from all sides. To the electricity generating industry, nuclear power represents an attractive way of reducing emissions. To most – but by no means all – environmentalists, the push for more nuclear power is both a mistake and a missed opportunity: a mistake because no country has yet shown that nuclear waste can be stored effectively, and a missed opportunity because nuclear baseload generation reduces the incentive to develop wind and tidal power.

This article looks at what we can learn from the building of the nuclear power station at Olkiluoto (OLK3) on the western coast of Finland. The ground works started here in early 2004 and the plant is now due to open in 2011. Does this project give us confidence that nuclear power stations can be constructed at a reasonable cost and to a reliable timescale?

OLK3 is Europe's first new nuclear reactor for over a decade. The UK's Sizewell B plant was commissioned in 1995 and since then most nuclear construction has been in Asia.

There are four existing nuclear reactors in Finland, operating on two sites. These reactors generate about 25% of Finland's electricity. The OLK3 project is located at an existing nuclear site and will provide a further 15% of total national power needs.

After regulatory inquiries lasting many years, construction was approved in 2001 and the preparatory site works started in February 2004. The contract with the French nuclear company Areva is a fixed-price arrangement that sees the Finnish owner paying about €3bn for the 1,600 MW plant.

The site was handed over to Areva in February 2005 with the expectation that the plant would be completed in the middle of 2009. Areva had quoted a construction time of 54 months, or four and a half years, from when it first controlled the site. At the moment of handover, construction appears to have been on schedule.

Since February 2005, there have been five separate announcements from TVO, the plant's eventual owners, giving details of the delays on the project.

OLK3 owner's expectations of completion date

Delay announcement	Date of announcement	Expected completion date	Implied construction period
Handover	February 2005	First half of 2009	53 months*
1	January 2006	Second half of 2009	59 months
2	July 2006	Second quarter of 2010	65 months
3	December 2006	Last quarter of 2010	71 months
4	August 2007	'2011'	More than 71 months
5	December 2007	Summer 2011 (assumed to be August 2011)	79 months

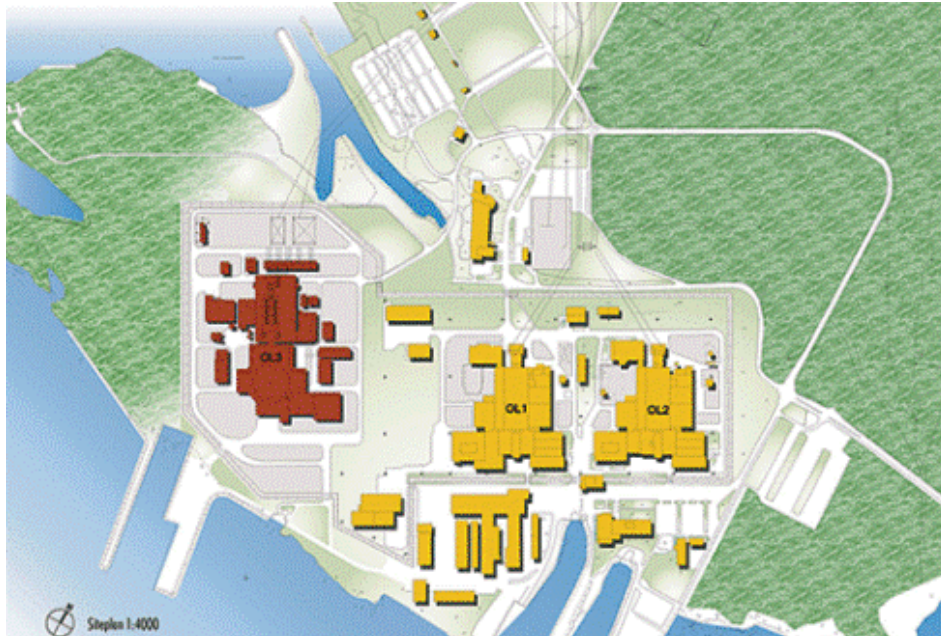
This table shows that in the 34 months since the Areva portion of the project began, the completion date has retreated by 26 months. Put another way, a 53-4 month project still has 44 months to run after it has been going for almost three years.

The reasons for the delays

Close reading of the press releases of Areva and TVO, and media comment, suggests a list of substantial problems with the project:

- Finnish and foreign subcontractors have been unable to maintain the quality of their work. Few European countries have recent experience of the requirements of nuclear engineering and the construction expertise simply isn't available.
- Some of the early concrete pouring was done at a time of year when it was likely to absorb too much moisture. This error was eventually noted by inspectors, who required a replacement of large amounts of concrete because of its high water content.
- The Finnish safety inspectorate has been more rigorous than Areva expected.
- Some of the huge metal castings have not been made to the quality and tolerances expected.
- The detailed engineering drawings for the project have been slower to produce than Areva hoped.

Until August 2007, TVO seems broadly to have accepted that Areva was doing its best. But in its press release of that month, TVO shows its first signs of irritation with the French company, suggesting that Areva had taken too long to tell it of the further delays it was experiencing.



Plan of the new Finnish nuclear reactor at Olkiluoto (OLK3)

The Finnish reactor is a prototype. It is the first of its kind that has been built, though it is a refinement of a previous design. Some of the delays do appear to be an almost inevitable result of the lack of experience of the company and its subcontractors. The less than adequate manufacturing of components and the problems with concrete may be a result also of inexperience. The French also appear to have been surprised by the problems of obtaining full engineering drawings and getting approval from safety inspectors.

It is still early days on this, Finland's biggest construction project, but there is no public evidence so far of any fundamental engineering problems. Although construction has been severely delayed and overruns have been substantial, there is no basis for concluding that Areva cannot construct a safe and well-functioning reactor here.

The financial consequences of the delays

The full cost of the project was initially projected a €3bn, although some of this was to be borne by TVO. Because it is a fixed-price contract, Areva has borne a large fraction of the cost of overruns. Examination of Areva's accounts and press reports suggests that the company made provisions for extra costs of about €750m in 2006 and probably a similar amount in 2007. So the total cost may currently be standing at more than €4.5bn.

There is conflicting evidence on whether Areva is having to increase the resources on the project to get it completed by 2011. In early documents, the company referred to employing a total of about 2,000 people on the site at the period of peak construction (which is probably this year). The number present in late 2007 was actually already 2,600, and only about one third of the labour force appears to have been Finnish, suggesting a need to import skilled workers from abroad. Other documents suggest large numbers of employees came from Poland, France, and Germany. As the project has progressed, the percentage of foreign workers on site has gradually increased.

The construction is financed by highly subsidised debt provided by a German bank as an export credit funded by the French state. (This arrangement is under EU investigation since export credits are usually only granted for sales outside the Union.) The interest rate – of less than 3% – is far lower than would have been granted if the banking had been done on commercial terms. The rate of bank interest matters greatly on long construction projects. If Areva is paid by TVO on completion of the power station, and the proper interest rate is, for example, 7%, then a year's delay might add as much as 7% to the cost of the project. OLK3 is already three years late.

Add the various extra costs together, and the total bill for OLK3 will probably eventually exceed €5bn or even €6bn. If it had been financed on commercial terms, the cost would have been even greater. An overrun of this size is by no means unusual in nuclear construction (see Greenpeace's analysis: '[The Economics of Nuclear Power](#)' [accessed 14 January 2008]). At this price, the capital cost will exceed €3m per MW of capacity and may rise as high as €5m.

The implications for any UK nuclear power programme

The Finnish power station may or may not be representative of problems likely to be experienced in the UK. In the last few months, Areva has begun construction of a second power station at an existing nuclear site in Normandy. The projected cost is €3.3bn and the construction time is estimated at 60 months or less. In other words, Areva is sticking with the numbers it produced when it won the Finnish contract and not suggesting that the actual experience there is likely to be a better estimate of the real cost.

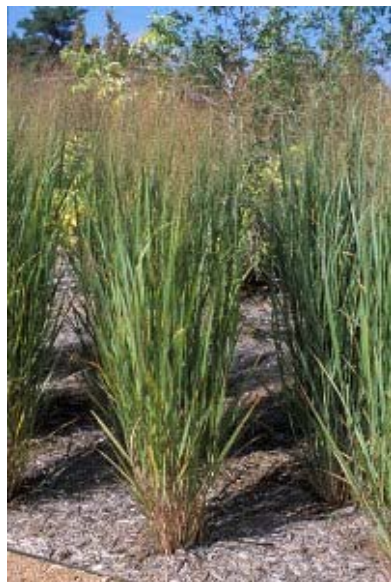
But whether Areva now feels it has learnt the lessons from OLK3 or whether it is simply being excessively optimistic,

the UK represents an entirely new challenge. Construction costs tend to be high and overruns are almost inevitable. Labour productivity levels are low, and project management skills are woefully lacking. It would seem prudent for Areva to offer a price in the UK that is at least 20%, and possibly 50%, above the levels it charges in the rest of Europe.

Areva reports that it has had enquiries from eleven utilities interested in having the company build a reactor in the UK. The company expects to build four or six nuclear power stations in the UK. Would they make financial sense? If Areva does achieve a cost of €3.3bn in France and a construction time of less than 5 years, nuclear energy probably costs less than 2p per kilowatt hour. This beats any alternative technology. Onshore wind is certainly more expensive. But if the true cost is actually double or triple this figure (which it most certainly would be if the Finnish experience is the right guide and we added a premium for the UK) then both onshore and just possibly offshore wind look better in strictly financial terms. A decision by a utility to press ahead with Areva's nuclear design (which is by far the most likely to be adopted in the UK) is, quite simply, a financial gamble on whether Areva's Normandy cost projections are correct, or whether the actual UK figure will be the Finnish cost inflated by a UK premium and the commercial cost of capital.

This is before considering the unresolved question of how we store radioactive waste.

The promise of cellulosic biofuels



Switchgrass biofuel crop

Will next-generation biofuels have a less destructive effect on agriculture? A study just published by US government scientists suggests that so-called 'cellulosic' ethanol has much better energy balance than today's biofuels.[1] By energy balance, we mean the energy used to make the fuel compared to its energy value when burnt in a car's engine. News summaries of the paper's contents focused on one estimate that suggested that to make cellulosic biofuels might only need 6% of the energy value contained in the fuel. Depending on which crop is used, where it is grown, and how it is refined, most of today's biofuels have only a weakly positive energy balance. So the paper gives hope that we might expect considerable progress towards carbon-neutral transport fuels when we can start refining all vegetable matter, not just foodstuffs, into fuels.

Cellulosic biofuels may well become important sources of motor fuels. There is certainly huge amounts of money flowing into the field. Unfortunately none of the news articles covering the US research pointed out the technology for turning cellulose into fuel is still a long way from commercial viability. Yes, we can turn grass into ethanol, but at prices which will double the price of petrol. And the greenhouse gas savings will almost certainly not be as attractive as the paper suggests, not least because the authors did not include the serious impact of nitrous oxide emissions from fertilised fields.

Today's biofuels are made from food. Whether it be wheat, sugar beet or rapeseed, biofuel refineries use materials that could be otherwise used for human or animal feed. As is now well understood, the competition between food and fuel is being won by the motor car, not human beings. It is not even a fair contest: humans need about 2,000 calories a day in food, but a UK car driver needs 40,000 calories a day to keep his car on the road in terms of the energy in his petrol.

This is the root of the biofuels problem. Even getting a small fraction of total motor fuel demand from agricultural crops requires us to turn large percentages of arable land over the petrol feedstock. To power the UK's cars would require us to turn over all the UK's cropland to fuel plantations. And, if we are not careful, this might happen. Your 2,000 calories of food a day is worth about 3p to a wheat farmer, but about 10p to a petrol retailer. In the US and the EU we actually rig the market even more in favour of fuels, giving subsidies to biofuel producers and telling retailers that they must include a percentage of plant-sourced ethanol in the mix at the petrol pump.

Biofuels are tending to crowd out food production – a point that is increasingly understood. But they also save little in the way of greenhouse gases. Growing a crop of sugar beet in an East Anglian field requires tractor fuel and fertiliser. The fertiliser creates the greenhouse gas nitrous oxide. The beet needs substantial processing, including a substantial amount of heat, before it becomes usable sugar. Then the sugar needs to be fermented into ethanol. All in all, the greenhouse gas savings are pretty minor, at least in high latitudes. Brazilian sugar cane ethanol is much better because it grows without fertiliser and the waste green matter is used for fuel in the refinery.

As oil runs out, what is going to stop us devoting all our arable land to service the needs of the world's one billion or so automobiles rather than its six and a half billion people? There are three possible answers:

- Extending the area given over to arable crops. Most countries only allocate a small fraction of their total land area to the growing of any form of crop. Poor or inaccessible land is given over to grazing animals, forestry, or left as 'set-aside'. We could increase the total amount of land under cultivation. England, for example, uses less than a quarter of its non-urban land for crops. Much of the rest is given over to animals. A large-scale switch to grains and seeds and away from animals would enable more food calories to be produced on the same area of land. But the *Financial Times* of 12 January reported that the sown area of US farmland will rise a surprisingly small 3.8% in 2008 even after the huge increase in the prices of agricultural commodities. It seems that the supply of crop-growing land is not very elastic.
- We could extend the area under cultivation around the world. Farmers' leaders consistently say that prolonged low prices for agricultural commodities have reduced the incentive for farmers in poor countries to use land for crops. This is a much stronger point than conventionally acknowledged: high prices will drag large acreages into production in less accessible and prosperous parts of the world. Will it be enough? It may be that commodities like jatropha do enable us to 'grow' motor fuels on land that is too dry or infertile for conventional agriculture, but the evidence as yet is far from compelling.
- We can hope for advances in cellulosic ethanol production. That is to say, instead of using food products for fuels, we could use the woody and straw waste materials from agriculture. This is the focus of many research groups and the piece of US government research covered in this article suggests considerable grounds for optimism.

It sounds easy to make a petrol replacement from woody waste. You dump it in a tank in which enzymes eat away at the lignin and cellulose and turn them into simpler carbohydrates. These carbohydrates are then fermented into ethanol (better known as 'alcohol'). The process seems simple. In fact Henry Ford thought that all car fuel would eventually be made from waste vegetation.

But so far the advances have been quite slow. There's no doubt that we will find a way of breaking down cellulose on an industrial scale. Sheep and cows do it, after all. However the enzymes needed to turn the fairly complex cellulose molecule into simpler carbohydrates are expensive to make, and, like making ethanol, the process still needs considerable amounts of heat. Very roughly, we might be talking about a manufacturing cost of £1.50 per litre at the moment, though it will come down.

The US government research suggests that eventually the net energy input from turning cellulose into ethanol will be very small. So, to put it another way, we will need very little fossil fuel to make a litre of ethanol, saving money, greenhouse gases, and reducing the oil import bill.

The researchers used a conventional American prairie grass as the source material. This grass ('switchgrass') grows on dry plains with low soil fertility. Unless the price of motor fuel rises to very high levels, it will not drive out the growing of agricultural crops. The project measured the typical yields from fields, calculated the fossil-fuel inputs necessary to grow and harvest the grass, and then estimated how much energy will be used to convert the cellulose to ethanol.

Their estimates of very low energy use to make cellulosic ethanol must be tempered by four important caveats:

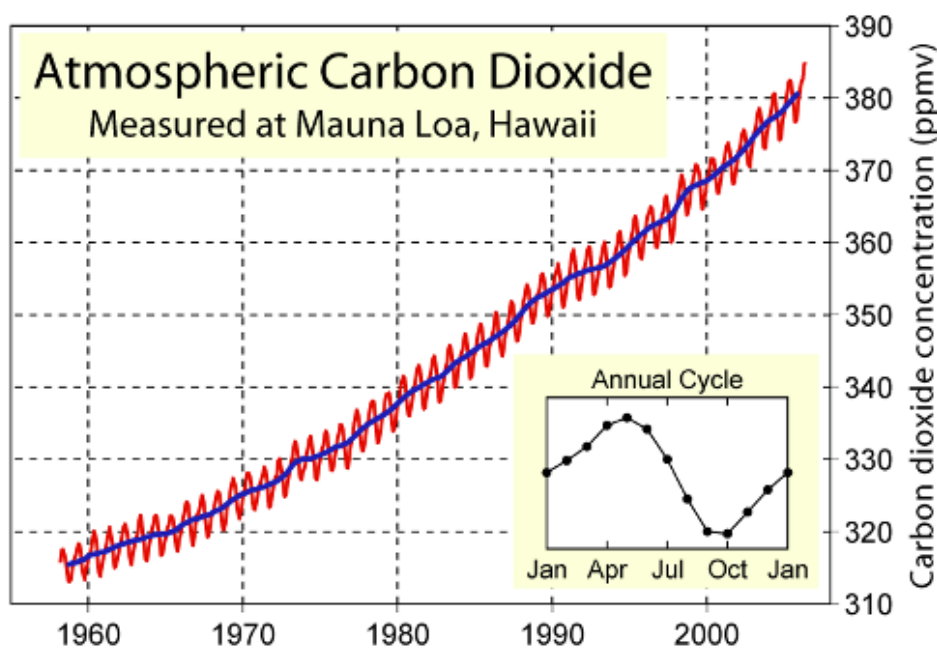
- The scientists do not appear to have calculated the impact of fertiliser use on the emissions of nitrous oxide. Although average fertiliser inputs were quite low (about 75kg of nitrogen fertiliser compared to an average of about 200kg to grow English wheat) the nitrous oxide emissions from this use may well mean that the net greenhouse gas savings from cellulosic ethanol are relatively small. Remember that the researchers were primarily looking at the impact on net energy need not on the relative greenhouse gas emissions of petrol versus ethanol.
- Their estimates of the manufacturing energy going into the production process are, at best, guesses. The paper should have been a little bit more transparent about this. And the scientists do not appear to have included the impact of actually making the enzymes to crack the cellulose.
- A large fraction of their projected savings come from the increase in soil carbon derived from turning the land over to permanent grassland. In other words, they are crediting the cellulosic ethanol with the carbon sequestration created by planting the grass. But this sequestration would have happened anyway if the grass had been allowed to grow uncropped. This is unfairly favouring the use of land for making fuels.
- Lastly, the lands that the researchers expect to use for switchgrass ethanol production are in the parts of the US most likely to suffer from desertification as a consequence of climate change. Large areas of the Great Plains were desert and may well become desert again within the next few decades. (Readers are referred to pages 5-7 of the UK edition of Mark Lynas's wonderful book, *Six Degrees*, due out in the US in the next few weeks.)

Cellulosic ethanol is one of the great hopes for technology fixes that may help reduce our use of fossil fuels. But the reality is that the greenhouse gas savings may not be anywhere near as much as this research suggests. Similarly, it may not decrease the pressure on food production as much as its proponents hope.

Footnote

[1] M. R. Schmer and others, 'Net Energy of Cellulosic Ethanol from Switchgrass', *Proceedings of the National Academy of Sciences*, 105.2 (15 January 2008), 464-9; <http://www.pnas.org/cgi/reprint/0704767105v1> [accessed 14 January 2008].

Carbon uptake by plants and trees is vulnerable to autumn warming



Carbon dioxide levels in the atmosphere rise by about 2-3 parts per million every year and the rate is slowly increasing. As well as this upward trend, there is an annual cycle: carbon dioxide levels fall in the northern hemisphere summer and rise strongly in the winter. The reason is that most of the vegetated land area is in the northern hemisphere and during the northern summer plants and trees absorb CO₂. One effect of increasing spring and autumn temperatures has been to increase the length of what is loosely called 'the growing season'. Plant growth can start earlier in spring and can continue until later. It might be thought that this would help vegetation take up more CO₂, acting as a counterweight to increased fossil fuel use.

Research published in *Nature* in early January very strongly suggests that this is not happening. Warmer autumns are associated with a bringing forward of the date at which plants start losing CO₂, not the reverse. Higher spring and autumn temperatures are tending to decrease the length of the period each year in which northern hemisphere plants are taking up carbon. If this research is confirmed, this is yet another potential positive feedback because higher temperatures might diminish the ability of biomass to take up carbon.

The article in *Nature* has an excellent summary of the issue:

The carbon balance of terrestrial ecosystems is particularly sensitive to climatic changes in autumn and spring, with spring and autumn temperatures over northern latitudes having risen by about 1.1 °C and 0.8 °C, respectively, over the past two decades. A simultaneous greening trend has also been observed, characterized by a longer growing season and greater photosynthetic activity. These observations have led to speculation that spring and autumn warming could enhance carbon sequestration and extend the period of net carbon uptake in the future. We find that atmospheric records from the past 20 years show a trend towards an earlier autumn-to-winter carbon dioxide build-up, suggesting a shorter net carbon uptake period.[1]

The research looked at records of carbon dioxide concentrations at a number of different stations around the northern hemisphere. The work showed that when autumn temperatures were particularly high, the date at which the carbon dioxide concentration started rising after its spring/summer contraction was considerably earlier than when temperatures were abnormally low. In a disturbing finding, the researchers showed that the date at which CO₂ levels started to rise each year is typically advancing over 0.3 days per year. If continued, this would mean that over the course of the next century the average date at which carbon dioxide levels start to rise will move forward one month. In spring CO₂ uptake starts earlier, but the advance is not as great as that in autumn. The length of the period of carbon uptake is decreasing.

Previous research has tended to suggest that global biomass uptake of CO₂ should rise until about 2050 and then stabilize. This research suggests that this conclusion is not robust and net carbon uptake may peak much earlier than this.

Footnote

[1] Shilong Piao and others, 'Net Carbon Dioxide Losses of Northern Ecosystems in Response to Autumn Warming', *Nature*, 451 (3 January 2008), 49-52; <http://www.nature.com/nature/journal/v451/n7174/full/nature06444.html> [accessed 14 January 2008; subscription required for full article].

Carbon capture at E.ON's Kingsnorth coal plant

E.ON's plan to install supercritical coal-burning technology on its Kingsnorth site in Kent was (unsurprisingly) supported by the planning authority. A more interesting question is why E.ON persisted with the application in the first place. Even carbon efficient power stations emit far more carbon than gas plants. A high price of carbon would make the Kingsnorth coal plant uneconomic. The answer to the question must be that E.ON is confident that supercritical coal plants can be economically retrofitted with carbon capture technology (CCS). So even if the carbon price increases dramatically, coal will still be competitive.



E.ON's planned Kingsnorth supercritical coal plant

E.ON's US operation is closely aligned with the co-operative FutureGen venture, which plans to build a coal gasification plant in the US within five years. This power station will then capture CO₂ and store it in sandstone. FutureGen gasification carbon capture technology is 'pre-combustion', unlike the 'post-combustion' focus in Europe. US electric utilities are now assuming that coal plants without CCS will not be allowed. But in both the US and Europe there seems to be a prevailing assumption that a \$30 per tonne CO₂ price is sufficient to cover the cost of CCS technology, meaning coal will eventually be back in the power station mix.

Kingsnorth power station is currently composed of two large coal-fired plants with two burners in each. With old technology, this power station would eventually have to have been closed under the EU's Large Combustion Plant Directive. E.ON has applied to switch the plant to using supercritical coal technology, which substantially reduces emissions. A typical old coal plant will produce 850g of CO₂ per kilowatt hour produced, but this is reduced to less than 700g for a new supercritical plant, saving 20% more of the carbon emissions.

Of course another benefit is that less coal is used. A new supercritical plant achieves 45% thermal efficiency compared to 36% at today's Kingsnorth power station (45% means that just under half the thermal value of coal is translated into electricity, with the rest disappearing as waste heat). An advanced supercritical plant will have the lowest emissions of any coal technology in the world and, with today's gas prices of 50p a therm, the lowest fuel bills.

Nevertheless, its carbon emissions will still be far higher than a new integrated cycle gas turbine plant at about 350g per kWh. This is other UK utilities are tending to favour gas for their new power stations. When E.ON made the decision to push ahead with coal at Kingsnorth, it must have known that a high CO₂ price in the European Emissions Trading Scheme could cripple the generating station. Putting £1bn down at Kingsnorth can only mean one of two things: either E.ON is convinced that coal prices will stay very much lower than gas for the next 20 years, even including a carbon premium; or, carbon capture technology is relatively close to commercial implementation so that it can afford to risk a high carbon price at some future date. Even for a company as large as E.ON, putting a £1bn down on a gamble that coal power stations will still be possible in ten years would be very brave if one didn't feel

that CCS would be available to insulate the company against a high price of carbon.

Contrast this optimism with a statement from a US power company that recently backed away from a new coal power station:

PacifiCorp has scrapped a plan to build a 527 mw pulverized coal unit in Sweetwater County.

A spokesman for the company told the *Casper Star-Tribune* that there is a 'significant amount of uncertainty about what climate change regulation might do to the cost of coal plants,' which makes 'coal projects no longer viable.'

'Within the last few months, most of the planned coal plants in the United States have been cancelled, denied permits, or been involved in protracted litigation.'

(From the *Casper Star-Tribune*, December 2007)

In the US, coal plants are being abandoned because operators cannot be sure that future regulation will allow their continued operation. In the UK, Kingsnorth indicates that utilities are actually confident of two things – first, that carbon capture will become available at a reasonable price; and second, that the price of carbon will be enough to warrant CCS. This is a big change over the past year.

Kingsnorth will probably be looking to use the Babcock CCS technology that will be trialled at the Ferrybridge coal station. This is a post-combustion technology.

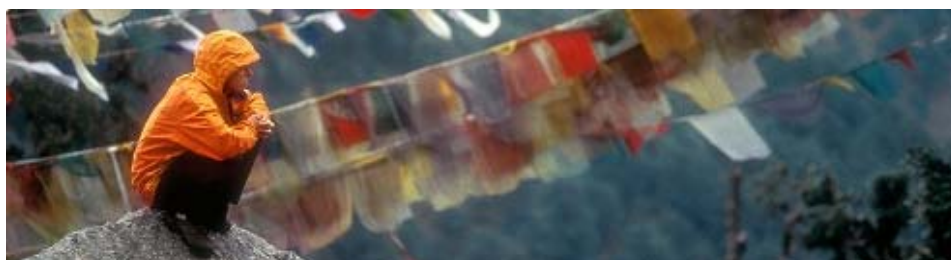
In the US, the public-private FutureGen partnership announced its preferred site in mid-December for a pilot pre-combustion CCS project. CO₂ will be captured from a coal gasification plant and injected into a sandstone rock formation several thousand feet below the surface. The gas will be captured in the pores of the rock and will probably never reach the surface again.



FutureGen's proposed carbon capture plant

The FutureGen plant may not actually go ahead. Though it is backed by big coal producers and electricity utilities, the government's commitment appears to be fading as the cost of the project increases. The original budget in 2004 was \$1bn but the cost has risen to over \$1.5b in three or so years as a result of steel and other price increases. This money only buys a 275 MW generator, compared to the 1600 MW E.ON is getting for about £1bn. It is an expensive experiment on a technology that will not be possible to retrofit to Chinese and Indian plants. It also requires large amounts of water and may never be economic.

Patagonia: a clothing company that wears its heart on its organic cotton sleeve





The US drags its feet in climate negotiations. A few hours after being harassed into signing the Bali accord, the White House started to distance itself from the hazy targets agreed by the rest of the developed world. But some American companies lead the world in environmental policies. The best businesses disclose more about their manufacturing processes and their carbon footprint than almost any European or Asian companies. One of the best examples is Patagonia, a highly-regarded maker of specialist outdoor clothing. To jaded European eyes, its environmental plans look almost embarrassingly earnest and idealistic. The admissions of its own weaknesses are delivered with a humility that we rarely see on this side of the Atlantic. What UK business would voluntarily describe the production processes of one of its key products as 'not sustainable'? Or admit that a complex chemical in the water repellent used in its outer garments (and those of all its competitors) is highly persistent and building up in the environment?

Patagonia's latest innovation is to document the full environmental impact of five of its products. Part of the company's website is devoted to analysing each stage in the production of these standard items. A polo shirt is tracked from the organic cotton farm in Turkey to the spinning factory in Thailand, eventually ending up in a warehouse in Nevada. From the cotton field to the warehouse is 14,000 miles. Patagonia says the CO2 produced is forty times the weight of the garment. The energy taken to make and transport the polo shirt could have been used to run a low-energy light bulb non-stop for 77 days. The waste involved in getting the product to the consumer is as great as the weight of the garment. If the polo shirt looks bad, the woollen sweater is even worse. The energy used to make this product would power the average US household for 20 hours.

The average UK shopper buys about 35kg of clothes a year, not very different from the US consumer. If Patagonia's figures are correct, our clothes purchases account for at least a tonne of global warming gases a year, or not far off 10% of our total carbon footprint. For a clothing company to advertise openly the high environmental costs of its products is brave indeed.

Patagonia has also allowed its customers to comment on its manufacturing processes. Some of the comments are highly critical, but remain on the website for others to see. Customers complain about the chromium used to tan its shoes. Or question why Patagonia's polyester products still contain antimony. Others attack the company's motives, or criticise it for producing almost all its clothes in the Far East. The comments are patiently answered and the company's flaws candidly acknowledged. The openness and apparently genuine transparency seem to stem from a view that Patagonia can admit to its mistakes and still have a far better environmental image than its competitors.

Anyone reading the Patagonia site must take away a message that clothing manufacture is far more environmentally damaging than its relatively benign image suggests. The true costs are hidden from view in a Chinese factory or Bangkok spinning mill. Patagonia acknowledges this, almost implying that we might choose to buy fewer items. Only a company with a deep self-confidence could possibly suggest that customers should defer buying its products.

Patagonia's mission statement openly acknowledges that the world faces 'an environmental crisis'. Unlike the many companies who have built a veneer of environmental respectability and then made exaggerated claims for their virtue, it simply says 'as yet, there is no such thing as a sustainable business'.

As a privately held company, Patagonia can perhaps more easily afford to pursue a strategy of genuine environmental transparency. Its customers will almost always be loyal buyers who love wild open spaces, and who have noticed the creeping impact of climate change and environmental despoliation on the places they love. Nevertheless, it seems a risky business strategy to identify the severe impacts of your manufacturing processes and to be willing to engage openly with critical customers. But I was convinced. I know that next time I need to buy outdoor clothing I will be actively looking out for the Patagonia label. As ethical considerations become more important to the British consumer, UK companies should think about following Patagonia's painfully honest lead.

Companies mentioned in this newsletter: Wimpey Homes, Potton, Kingspan, Areva, TVO, E.ON, FutureGen, Patagonia.

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