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CONTENTS

» p 02 **How deep sea aircon could cut the heat of climate change**

The deep ocean is cold; our cities are growing increasingly warm. What if we could tap those frigid depths to cool energy-hungry metropolises? By **Chris Pala**

» p 04 **Don't buy it - hire it: the real green consumer** It's an unfashionable idea, but would a return to hiring products and services rather than buying them help us reduce our ecological footprint and turn businesses green? By **Ewan Kingston**

» p 06 **Lab grown meat: A low-fat, low-carbon, cruelty-free future?** The technology isn't fully developed yet, but when meat really can be grown in a lab it's going to turn our arguments about carnivorous diets on their heads... By **Matilda Lee**

» p 08 **What is the health impact of air pollution?** After the Clean Air Acts banished the smogs of the 1950s and 1960s, many thought that air pollution problems had disappeared. They were wrong. By **Andrew Marszal**

» p 10 **Can our electricity grid cope with all the new wind power?** Wind energy finally seems to be moving somewhere in the UK, but without new techniques, our grid is simply not going to cope with this flood of new green power. By **David Strahan**

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- » Turning a draughty Victorian terrace into an ecohome
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- » Our top three UK alternatives to olive oil
- » How to be an urban beekeeper
- » Bond markets rule our future

Number 10: look at the numbers



So, we've had the last debate, we've had 'Cleggmania', we've had 'Bigotgate'. In one of the most closely fought elections for decades, it looks as though there's still all to play to for.

Except that really, there isn't. Whichever hue of prime minister ends up in Number 10 this May, he will be placing his limbs into exactly the same resource manacles as the two other contenders.

No, I'm not talking about the budget deficit, although as our columnist Dan Box recently pointed out, the national debt has now made us slaves to one of the fiercest, most unforgiving markets of all – the international bond market.

I'm referring instead to the fundamental resources of society, which, unfathomably, have been given scarcely any airtime at all during the election campaign.

Take energy. The closest the subject came to discussion during the leaders' debates was for an exchange of fire over support for nuclear power. Nick Clegg pointed out, quite rightly, that nuclear power is expensive, and that cheaper solutions exist. But by dismissing nuclear power – as Professor David Mackay showed in his myth-busting book *Renewable Energy Without the Hot Air* – you'd better have a plan for renewable energy so good it makes Denmark look like the back yard of an Exxon CEO.

Unfortunately, there isn't much sign that any of the main political parties have fully thought through the huge impact on our electricity grid that both today's and tomorrow's energy policies are likely to have, as David Strahan points out in this issue of the newsletter.

Other resource issues include water availability, an issue that was brought starkly to our attention by two reports in April.

The first, produced by the insurance group Lloyds, argues that water shortages around the world are directly contributing to agricultural price instabilities – surely a key issue for a country that has consistently made its larder the free market, trading dodgy City derivatives for our dinner?

The second report came from the highly respected International Water Management Institute, and warned that clamouring – as western governments frequently do – for a doubling of food production by 2050 without tackling water efficiency 'doesn't add up'.

And perhaps the leaders, busy trumpeting the new future manufacturing and hi-tech economies, would have done well to read an analysis on the impacts of rare-earth metal mining by two ecologists, Oswald J. Schmitz and T.E. Graedel, published by online magazine *Yale Environment 360*:

'Anyone who relies on modern electronic technology and favours the development of green technology – environmentalists and technocrats alike – has a shared link to environmental damages ensuing from mining,' they wrote.

To our new prime minister: out of sight on the campaign trail must not mean oversight when in office.

Mark Anslow, Editor

Downtown Honolulu, soon to be cooled by ocean aircon



HOW DEEP SEA AIRCON COULD CUT THE HEAT OF CLIMATE CHANGE

The deep ocean is cold; our cities are growing increasingly warm. What if we could tap those frigid depths to cool down energy-hungry metropolises? By **Chris Pala**

Until the 1960s, when jet travel brought mass tourism to Hawaii and skyscrapers began sprouting from Waikiki to Pearl Harbor, Honolulu was a city of widely spread-out low buildings shaded by giant monkeypod trees and naturally cooled by the strong trade winds that blow 2000km north of the equator.

Today, however, a forest of concrete structures that not only trap heat but emit it through air-conditioning have turned the city centre into a heat island and have become a drain on the state's over-extended power generation system.

In the next few months, work will begin on a project to make Honolulu the first city in the

world to have its heart cooled by seawater pumped from the deep. This will save building owners money in several different ways and at the same time cut greenhouse emissions, according to an environmental impact statement published last autumn.

The technology is already used in parts of Toronto and Stockholm to balance temperatures inside large buildings, notably to cool areas with computer servers and telephone exchanges during the summer months. But, says William M. Mahlum, president of Honolulu Seawater Air Conditioning LLC, which is undertaking the \$240-million project, 'this is the first time it will be used to cool a warm-weather city center.'

A sea of history

It's not surprising this first came about in Hawaii. It was on the Big Island in 1974 that the Natural Energy Laboratory of Hawaii Authority (NELHA) began the first US tests of Ocean Thermal Energy Conversion (OTEC) technology to see if temperature differences between the deep and the surface could be turned into electricity economically.

In 1979, a barge dubbed 'Mini-OTEC', anchored off Keahole Point, demonstrated that OTEC was indeed a viable energy source, producing a net 15 kW of electricity by exploiting the temperature differential between water from 670 metres at 5.6°C, and surface water at 26°C.

The technology was simple and robust (it is still working today), but at the time did not produce electricity at an economically viable price. A later project set about pumping the cool water through heat exchangers, and the notion of ocean-fed air conditioning was born.

Ground is expected to be broken on the new project this summer, and the first 40 buildings are expected to come online in late 2012. Another five will be added the following year.

The system will save its clients about 20 per cent in cooling costs, the company says, and by reducing power use by 77 million kWh/year, or 75 per cent of the present consumption, it will cut carbon dioxide emissions by 84,000 tons a year, nitrogen oxides by 169 tons and sulphur oxides by 165 tons. It will also reduce the use of refrigerants like HCFC-22, HCFC-123 and CFC-11/500 and save 260 million gallons of drinking water each year.

In addition, it will end the dumping into Honolulu's sewers of 84 million gallons per year of used cooling tower water containing chemicals such as phosphoric and sulfuric acids, aromatic amines (for corrosion, scaling

'Most green energy projects focus on generating clean electrons; this one avoids electrons altogether'

and fouling control), difluoroethane (microbiological control and insecticide), as well as chlorine and isothiazolin (microbiological control), according to Ingvar Larsson, Honolulu Seawater's Vice President of Engineering.

'Most green energy projects focus on generating clean electrons,' says Jeff Mikulina, head of the Blue Planet Foundation, whose goal is to promote clean energy in Hawaii, which gets more of its power from burning oil than any other state. 'The beauty of this one is that it avoid electrons altogether by tapping into a vast local resource.'

The process

Here's how it works: a five-foot-wide pipe extends four miles out to sea to a depth of 1,700 feet, bringing in 44,000 gallons of water every minute at 45°F (7.2°C). Once ashore, the water is fed into a conventionally powered chiller that brings it down to exactly 44°F (6.7°C), then flows through a heat exchanger with a closed-circuit freshwater system and is released back into the sea at a depth of 200 feet at 56°F (13.3°C) – the natural temperature at that depth.

Meanwhile, the cooled freshwater makes its way to the buildings' air conditioning units and cools the air flowing over the chilled coils. This allows the building to turn off the energy hungry compressors that previously did the same job.

Hawaii, like many warm climate locations, sees a surge of power demand in the middle of the day driven by air conditioning, so the ocean-fed system would not only save power, but premium power, which is often provided by the dirtiest power stations. 'This project will help relieve some strain on the power grid,' notes Mikulina.

One concern might be that the system would locally raise ocean temperatures – a problem that has been noted around the outputs from water-cooled power stations. Not in this case, says Ingvar Larsson, Honolulu Seawater's vice president of engineering. 'If you look at the heat we emit in both the ocean and the atmosphere, it's 40 percent less than a conventional air conditioning system, and of course by cutting greenhouse gases, we slow global warming,' he says.

Even so, marine microbiologist David M.

Karl warns that the water at a depth of 700 feet contains more nutrients than the water at 200 feet, so releasing warm, nutrient-rich water at shallower depths could lead to a rapid increase in biological activity.

'We'll be monitoring to see if it creates an algal bloom,' adds Karl, who heads the Laboratory for Microbial Oceanography of School of Ocean and Earth Science and Technology at the University of Hawaii at Manoa.

The project even has fans amongst conventional utilities, which are ultimately losing business as a result of its installation. Peter Rosegg, a Hawaii Electric Company spokesman, has nothing but praise for the project. 'By reducing our load, it allows us to increase our reliability to other customers,' he says.

The system will reduce electricity generation in Hawaii by only one per cent – one year's worth of growth in demand. But Rosegg says, 'one per cent may not seem like much, but this is an important one per cent because the downtown area has banks and medical centers that require very reliable power. They can't afford dips and curls, and seawater cooling is much more even than, say, wind and solar power, which go up and down a lot.'

Future steps

The next logical place for an ocean-fed air conditioning system would be Waikiki, the Honolulu neighborhood just east of downtown, which has also become a Manhattan-like forest of skyscraper condominiums and hotels. Over one third of power use there is for air conditioning. Honolulu Seawater Air Conditioning officials confirm that once the current project is finished they expect to create another unit in Waikiki, with its own pipe into the ocean. This would take another five years.

Once the first system is up and running, however, it should inspire tropical coastal cities around the world to harness the technology, predicts Mahlum. 'All you need is a steep enough coastal gradient and concentrated demand,' he says. 'We've commissioned a study of U.S. cities and found that it would work in more than 30 of them.'

Just where those 30 cities are, however, is still 'commercially sensitive information'.

Chris Pala is a freelance journalist

'If you look at the heat we emit to the ocean and atmosphere, it's 40 per cent less than conventional aircon'



Don't buy it - hire it: The real green consumer

It's an unfashionable idea, but would a return to hiring products and services rather than buying them help us reduce our ecological footprint and turn businesses green? By **Ewan Kingston**

Picture a world where products are manufactured to be extremely durable, upgradable and reliable. When finally obsolete, all of a product's parts would be carefully conserved, and not 'downcycled', but remanufactured to make exactly the same product.

In such a 'closed-loop' world, customers would get the use of high-quality everyday items, and the energy demand of industry (currently one third of the world's total), would be slashed – primary resources would no longer be extracted and processed on anything like the scale they are today.

It's a nice idea, but with massive interests in the status quo and resistance to government regulations, how can we get there?

Many green business leaders believe the path to a closed-loop technological world makes perfect business sense. The interesting thing is, the path they believe will get us there involves what has become a rather unfashionable idea – hiring things.

The sale-of-service (sometimes called product-of-service) approach is the revolutionary green idea that instead of buying products, we should, for many durable goods at least, only

buy or lease the service for which we use the product. In that case, the physical stuff will always remain the property of the company that produced it. Vehicles, buildings, carpets, even a window manufacturer can instead of selling windows sell what Michael Braungart, one of the fathers of the product-of-service approach, calls '25 years of looking-through-insurance'.

Hirer is king

The benefits to customers are many: they won't be left with the liability and increasing cost of disposing of a possibly toxic item at the end of its life. Product-of-service items will also tend to be more reliable and upgradable, as the manufacturer's business model will give them an incentive to extend rather than shorten the lives of physical products. In addition of course, sale of service will often hold one of the benefits of the traditional lease – the opportunity to cancel the service after a certain term.

Manufacturers also benefit from retaining ownership of their valuable materials.

Braungart points to materials that are rapidly becoming scarce, such as the metal, indium. If products containing such precious materials are sold in the conventional way, manufacturers are effectively throwing away expensive resources that they could retain under a sale-of-service arrangement. Another advantage is the stable, predictable income stream that would result from a leasing arrangement - music to the ears of business-people who have endured the financial rollercoaster of the last 18 months.

Finally there's a marketing benefit to those who adopt the product-of-service approach. Steven Bolton, Senior Consultant at McDonough Braungart Design Chemistry puts it this way:

'If you are recycling a material then you as a manufacturer or a company are connecting with the customer to get that material back after use... that customer contact allows you the opportunity to show yourself in a positive light and is even a chance to sell to the customer again.'

You might think sale-of-service is already with us. We rent big ticket items – houses,

some white goods and, increasingly, cars.

But at a closer look, this is not the kind of business model that will change our manufacturing practice, as the leasing is fitted into the usual system of ever-increasing consumption. As Paul Hawken, Amory and Hunter Lovins wrote in *Natural Capitalism*: 'a traditional capital lease of equipment [is] often based on the hope of 'churning' – re-leasing new and improved equipment once the first term expires'.

Existing models

Sale-of-service is only green if it can transform the design of the product in question. A perfect incentive for a car manufacturer to create a truly energy efficient car is if the cost of running it is to be included on a per mile basis in the lease they offer. A great incentive for a construction company to create a truly durable building is if it was to be leased by them directly, not from a landlord who has purchased it.

So we are a long way from the revolutionary approach our economic visionaries talk of. But the closer you look, the more examples of genuine sale-of-service you can find. GE Aviation is said to only lease, not sell, its aircraft engines. Dow Chemicals even leases solvents through its subsidiary, Safechem. And the practice has become almost standard in the photocopying industry – machines are often leased to businesses on a per-copy basis by the manufacturing companies. It's a true sale-of-service model: Xerox can re-use 80 per cent of the equipment it provides to businesses, and says the one million tonnes worth of product it has reclaimed has saved the company \$2 billion.

There are also 'effective leases' – construction technology firm Caterpillar, for example, reclaims its materials from customers at a rate of 94 per cent, and uses them in their own 'Reman' (remanufacturing) programme. Shaw and Interface both offer free depending on the current price of raw materials. Given that disposal costs continue to rise (landfill tax will continue to rise by £8 per tonne per year in the UK until at least 2014), the effect is that customers are effectively penalised if they don't return the goods to the manufacturer at the end of the service life.

These are exceptions though, rather than rules – plain old products are still the order of the day. Buy 'em, use 'em, throw em out. Which begs the question, if sale-of-service makes sense why don't we see more of it?

One of the biggest barriers to a manufacturer adopting the sale-of-service model is financial. Sale-of-service has great long-term potential to be profitable, but it does require a large and expensive up-front capital investment by the manufacturer, as there is a long lag before the cost of producing an item is repaid by the customer's regular payments.

Hugo Spowers is the CEO of Riversimple, a

company developing an ultra-efficient hydrogen car, or rather, 'personal transport service', as the car itself won't be sold. Gaining sufficient working capital has been one of the challenges for Riversimple: 'The numbers really stack up – it's a much more profitable model than selling a car. But the problem is it's a new technology, it's a new business model and it's a new company,' he says.

Spowers believes it's only a matter of time before financial institutions cotton-on to sale-of-service models like Riversimple's. 'Once you've proven the model and the technology, debt will be much easier to acquire and much cheaper,' he says.

The financing problem would also be eased if

'At one point we started to make owning stuff into a religion. But most of it we don't "consume" - we just use it'

the companies supplying parts to a manufacturer also operated on a sale-of-service model. Thus making a hydrogen car would involve initiating the lease of a hydrogen cell, electrical system and other parts of the car, rather than a large capital outlay.

Turning business on its head

A paradigm shift is also needed from the marketing side of companies. Steven Bolton says: 'Companies are used to selling a product and getting rid of it, in a way. The [current] connection with the customer is just "you bought our product, great, I hope you come back again". Product-of-service is a positive approach, not just "less bad". It's a real switch in people's minds.'

A switch is needed in the minds of business customers as well as manufacturers. Large companies often operate under the premise that purchasing is always preferable to leasing (as an example Spowers cites the IBM management manual). Their reasoning is that as a huge company, their cost of borrowing (or 'cost of capital') is lower than the service provider's. Thus paying someone else to bear their higher capital brunt of leasing out a product over a long period makes no sense.

'What that completely ignores,' says Spowers, 'is that if we were going to sell a car we would sell a completely different car.' The durable, low-maintenance, energy efficient model that the company is offering only

makes economic sense to the client and the manufacturer under a sale-of-service arrangement, with the manufacturer fuelling the car at a fixed rate per mile.

The numbers do seem to stack up. The ballpark figure of £200 per month that Riversimple may charge might seem a lot, but when you realise you would be getting a fully serviced, cutting edge hydrogen vehicle (perhaps even including insurance), it seems much more reasonable.

Changing our psychology

So are there other, irrational reasons for the slow take-up of sale of service models? Psychologist Tim Kasser sees our sense of identity as a big one: 'The psychological barrier [to the service-product approach] I think, boils down to the problem of ownership... people derive their identity in part from their possessions, and to rent rather than own could interfere with that sense of identity.'

But Kasser is quick to point out that our identities are not set in stone: 'There might be a type of identity that could be developed in renting rather than owning - I am free of the burden of possessions, I am living more ecologically-consciously.'

Michael Braungart goes further. 'At one point, we started to making owning stuff into a religion. All our products which we use on a day-to-day basis are actually services. Whether its a washing machine, a car or a TV, we don't "consume" this stuff, we really only use it.'

Like Bolton and Spowers, he talks of a paradigm shift, this time on a personal level. 'As soon as you understand that you cannot take anything with you when you die, you begin to see these things differently.'

Mysticism aside, is there also a systemic barrier to the adoption of sale of service models? Tim Kasser: 'Right now, the goal of the culture is to encourage a psychological mindset focused on ownership of private property, because that has important economic ramifications. Shifting that cultural dynamic towards rental rather than ownership will not be easy, but there are lots of people writing about moving away from the fetishism of economic growth.'

Other theorists like Braungart and Spowers talk less about avoiding growth fetishism, but much more about self-regulating systems that don't 'draw down' on 'natural capital'.

It may be hard to imagine exactly how we will transform our current high-throughput society to a closed-loop model, but product-of-service must be a key concept. One thing is clear: what such the ideal system doesn't look like. 'I no longer believe we can have a sustainable industrial society based on sale-of-product,' says Spowers. Long live the true service economy!

Ewan Kingston is a freelance journalist



Lab grown meat: A low-fat, low-carbon, cruelty-free future?

The technology isn't fully developed yet, but when meat really can be grown in a lab it's going to turn all our arguments about carnivorous diets on their heads... By **Matilda Lee**

Veteran US food campaigner Michael Pollan famously said: 'Food should be alive, and that means it should eventually die.'

A simple truth, but how does it apply to the emerging science of laboratory-grown meat? Is something that originates from a stem cell, is grown inside nutrient-rich liquid, and is mechanically stretched to increase its size and protein content, ever really alive? Once cooked, what would in vitro meat be like – steak or roast? Drumsticks or chicken breast? Gammon or chops?

There is no end to the types of questions 'cultured', 'in vitro' or 'lab grown' meat throws up. But supporters claim the technology will help bring an end to many of the ills for which the conventional meat industry is blamed, from excessive greenhouse gas emissions to pandemic zoonotic diseases, food-borne

illnesses and widespread farm animal abuse.

At least another five to 10 years will pass, scientists say, before anything like it will be available for public consumption, but in vitro technology has the potential to revolutionise the meat industry - while catering to the demands of the world's increasing population of hungry carnivores.

The way it works

The first taste of this technology will likely be boneless, processed meat, similar to hamburgers or chicken nuggets. Lab-grown steak, chicken wings, or pork chops at this stage, are out of the question.

'Right now the tissues can only be grown in very thin layers. The way that live animals grow thick tissue is with blood vessels, but

creating blood vessels in a lab is still technically impossible,' says Jason Matheny, director of New Harvest a non-profit group that funds in vitro meat research.

In vitro meat uses techniques to engineer tissue, and is not the same as animal cloning. It works by taking a myoblast, a precursor to muscle tissue, and immersing it in a culture medium (a nutritious soup of water, sugar, amino acid, vitamins and minerals in which the cells can grow). As the myoblasts fuse together, muscle fibres are formed.

All of this takes place inside a bioreactor, a fancy name for something as small as a petri dish or as large as an industrial 10,000 litre vessel. Producing the tissue takes between four and five weeks, whether or not you are making one kilogram or one tonne.

'You depend upon a stock of stem cells that

you are constantly recharging, it could be poultry, pork or beef,' says Matheny. So, how long until it goes off? 'That's actually an open question. It should have a longer shelf life because you are producing it under more sterile conditions. But this aspect hasn't been looked at.'

Green meat?

It's too simplistic to say that all meat eating is harmful to the environment, but what's clear is that meat production at the moment has an enormous environmental footprint that will only grow as the industry grows, as anticipated, to twice its current size by 2050.

So could in vitro meat reduce this impact? Hanna Tuomisto, of the University of Oxford's Wildlife Conservation Research Unit, and M. Joost Teixeira de Mattos of the University of Amsterdam have performed a life cycle assessment of cultured meat production (funded by New Harvest and currently in the process of submission to a scientific journal) which found cultured meat had 80-95 per cent lower GHG emissions, 98 per cent lower land use and 90-98 per cent lower water use compared to conventionally produced European beef, lamb, pork and poultry.

The study did not involve direct data, but was instead scaled up to an industrial level using lab data. As such, and because the technology is still so young, it is hard to know

own waste, in giant metal sheds, doped full of antibiotics and growth promoting hormones – then I think producing meat in sterile facilities under tightly controlled conditions looks like an advantage.'

He's not alone in this view. Animal abuse in factory farms has so motivated activists that animal rights group PETA is offering a \$1 million prize to the person who comes up with an edible in vitro meat product.

PETA Director of Special Projects, Poorva Joshipura says: 'In vitro meat, when fully developed, will provide the meat addict with all the taste and texture of the real thing, but with none of the suffering, filth and environmental devastation, making it the most progressive food source possible.'

In vitro meat would also be free from hormones and antibiotics as well as contaminants such as salmonella and campylobacter. Its fat content could be tightly controlled and, because you could have a bioreactor anywhere in the world, meat production could become more dispersed. Matheny says they've seen 'significant interest' in the technology in Asia [Singapore and India in particular] where meat consumption is rising dramatically.

In 2005, researchers from three Dutch universities received a grant from the Dutch Ministry of Economic Affairs to further in vitro meat technology. They were tasked with overcoming two big scientific obstacles that prevent in vitro meat from being commercial-

Stegeman (at the time part of Sara Lee Foods Europe and now a Smithfield Foods subsidiary) was a condition of the first grant, and has now ended.

Even so, it's likely that the expense and physical form of early in vitro meats will mean that it will be brought to market by big food companies. Jim Thomas, of watchdog group ETC writes in the *Ecologist*, 'If test-tube meat hits the big time, we will likely know by its appearance in a Big Mac or when agribusiness buys out the patent-holder.'

However, while Matheny says that meat processors had shown interest in the initial research, he disputes the idea that Big Ag would be able to exert as much control as it does in the current industrial meat industry.

'It's unlikely for there to be a monopoly – it is hard to buy up all the technology. There are lots of different pieces of technology involved in producing cultured meat, which means that there are lots of different systems and processes to optimise, which also means there are different intellectual property issues [different culture media formulations, different bioreactor designs] to carve out.'

Family farms in danger

In vitro meat bears no resemblance to food production as we know it – it doesn't involve a farmer, land, or even a real animal. At the same time, when considered next to the factory farms exposed in films like *Food Inc.* or *Pig Business* – it is cruelty-free, low carbon and potentially environmentally-friendly.

What we would stand to lose with cultured meat is the whole idea of provenance – the local, well-reared, skilfully butchered cut of meat. And with it, the kinds of small, family farms and communities that support it.

Unsurprisingly, supporters of small farms are sceptical. Soil Association spokesperson Clio Turton says: 'We haven't seen any evidence that this is safe for human consumption. There may be unforeseen consequences of growing meat this way. Growing meat in a petri dish is odd. We can't imagine it would replace meat production in the UK.'

It is so odd that it almost seems beside the point to wonder what it tastes like. Does it actually taste any good? 'It's not an approved foodstuff so it is hard to get anybody to own up to tasting it,' says Matheny.

But everyone I asked who is involved in developing the technology says that they would eat in vitro meat willingly. Matheny, who is a vegan, says he would eat it. Roelen points out that, as is the case with processed meat, the taste is not from the actual meat – it's in the way it's processed and the ingredients added. 'Give it some garlic, pepper and salt and there'd be no difference,' he says.

Matilda Lee is the Ecologist's Community Affairs Editor

'In the US, 90 per cent of meat comes from factory farms, but people still have this picture of a bucolic farm'

how robust its conclusions are, but it seems likely that in vitro meat would fare well on these fronts compared to conventional meat.

This would put it on a par with other, more environmentally-friendly meat alternatives like Quorn, a popular meat substitute made from mycoprotein (a fungus fermented in a glucose solution). In an initial life cycle analysis performed in conjunction with De Montfort University, Quorn was found to produce considerably less greenhouse gases than beef and require significantly less land.

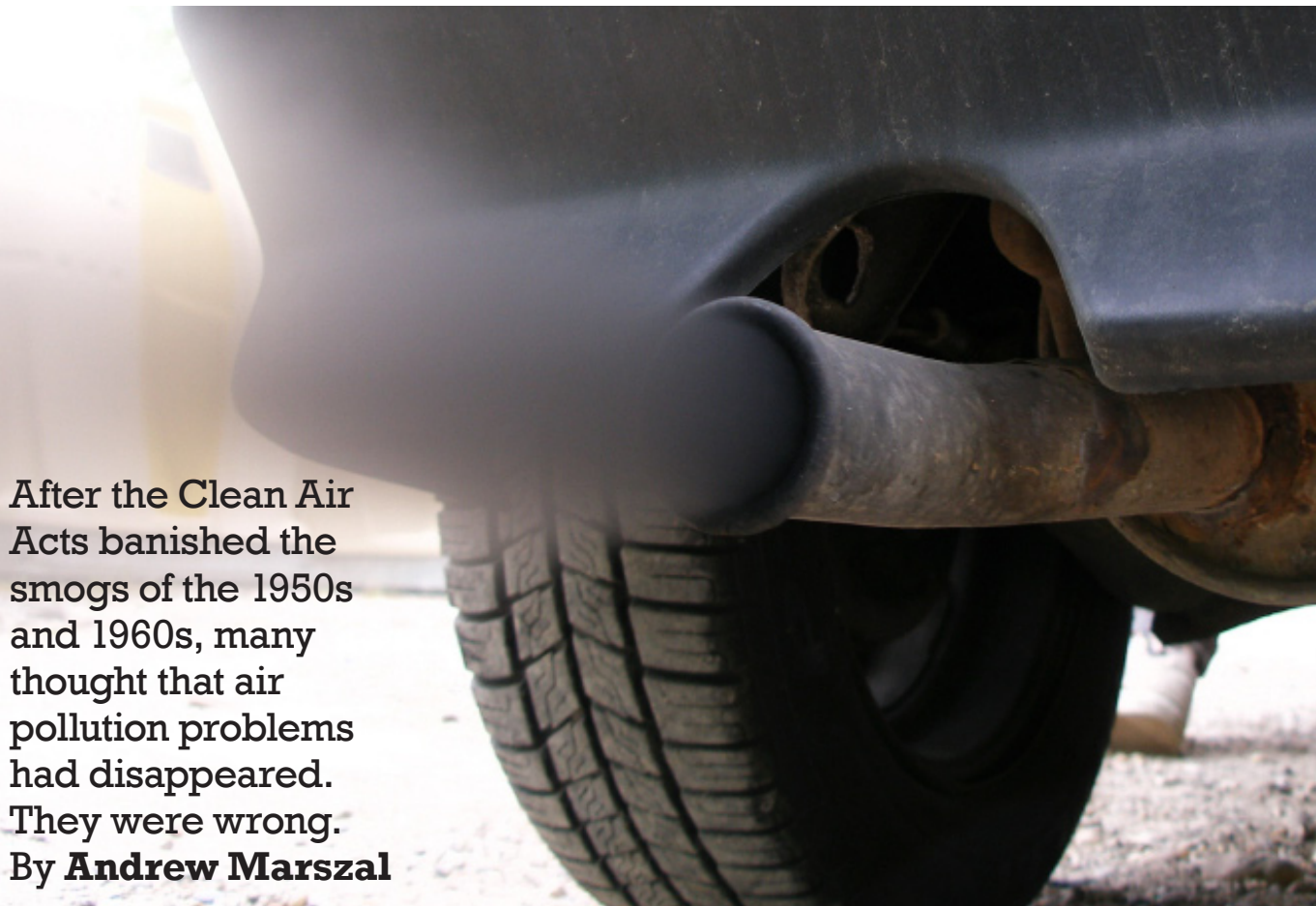
But meat has a particular taste and texture that many people feel is without substitute. Matheny argues that creating meat in vitro offers many health advantages, but that consumers – in America and, increasingly, elsewhere – must face up to where most meat actually comes from.

'In the US, about 99 per cent of the meat produced comes from factory farms, but people still have this unrealistic picture of a bucolic farm where their meat is grown. When one looks at the reality – tens of thousands of animals, confined very tightly, living in their

ised: developing the particular stem cells needed, and finding an economically viable alternative to the existing culture media.

Bernard Roelen, of Utrecht University, who is involved in the stem cell research says that they are just continuing the research of Dutchman Willem von Eelen, an entrepreneur who in the 1950s developed the idea of using tissue culture to produce meat, although he naively thought that you could take muscle cells and culture them. Roelen's work studies how to culture the skeletal muscle cells from specific animal stem cells. Dutch researchers have also started work on a culture medium they say will be much less expensive than the one currently produced for biomedical purposes, using micro-algae and photosynthesis.

They are now applying for another government grant, this time with the Ministry of Agriculture. Roelen says industry is hesitant to commit funding, with companies saying they need more evidence the technology is feasible before they invest. An initial collaboration with the meat business Meester



After the Clean Air Acts banished the smogs of the 1950s and 1960s, many thought that air pollution problems had disappeared. They were wrong. By **Andrew Marszal**

What is the health impact of air pollution?

Air pollution – seen by most of the population as an outdated public health issue – has returned to mainstream media attention in recent months. March saw a widely-reported publication from the Environmental Audit Committee, which said the UK should be ‘ashamed’ of its poor air quality.

There has been debate in the House of Lords, and threats from the European Commission of multi-million euro penalties for halfhearted British efforts which have failed to meet mandatory air quality targets set five years ago. The BBC and other outlets have also investigated fears that the London Olympics will be jeopardised by a blanket of pollutants spewed from congested traffic.

Meanwhile, activists have employed new media technologies to increase air pollution’s profile. The Campaign for Clean Air in London,

for example, has generated interest through a Twitter campaign aimed at exposing a ‘government cover-up’ over annual pollution-caused deaths.

There is even a new air quality iPhone app from Kings College London, which offers Londoners real-time updates on kerbside pollution levels in their area. It gained 6000 subscribers in its first two weeks.

Growing awareness

The driving force behind these trends is an ever-increasing medical understanding of air pollution’s impact. Certain groups were already known to be badly affected by poor air quality, including asthmatics and those living near to major roads or construction sites, but awareness of wider impacts was low.

Four years ago Defra commissioned a study

to examine what a Citizen’s Jury thought about air pollution. The sample group recorded that they had ‘no sense of what “good” quality air is’. Indeed, most participants admitted that they had never explicitly thought about air quality.

It is becoming more difficult to avoid the issue. Crucially, new research is linking poor air quality to heart disease and impaired lung function on a wide scale.

But this attention has not yet translated into the widespread public concern needed to force political action. This is proving difficult with a public sceptical of an invisible health threat, and medical research into the matter still at early stages.

Poor air quality is now thought to cause 35,000 or more premature deaths in the UK each year. If it is to be tackled, a greater public

awareness of medical research into air pollution – including its shortcomings – is necessary.

The science

So what is this new research? As has been widely reported, long-term exposure to traffic-generated pollution is now strongly linked with cardiovascular and respiratory disease. This is the conclusion drawn from numerous prominent epidemiological studies.

One of the first of note was the result of work by a Dutch team based at the University of Utrecht in 2002. They used a large random sample of people approaching retirement age from across the Netherlands to compare heart and lung disease mortality with traffic exposure. Over a 12-year period, those living within 50 metres of a major urban road were found to be almost twice (1.95 times) as likely to die from cardiopulmonary disease.

A more recent German study carried out in 2007 at the University of Duisburg–Essen – located in the highly industrialised and densely populated Ruhr region – unveiled similar trends. It noted that calcification (the build-up of calcium deposits) within the coronary arteries increased alongside proximity to major roads. Residents living twice as close to a major road as their neighbours could expect to suffer on average 7 per cent higher levels of calcification, which is linked to heart attack and stroke.

In addition to heart and lung disease, several studies have looked at the impact of traffic pollution on birth outcomes. A University of British Columbia team in 2008 assessed over 70,000 births across three years, and found cases of small gestation age size and low birth weight rose by 26 per cent and 11 per cent respectively within 50 metres of highways. It also found a correlation between exposure to particulate matter – which is generated by brake and tyre wear as well as by engines – and premature births. All of these outcomes have long-term associations with developmental disability and chronic lung disease.

This selection is representative of a wider consensus being forged by research. The studies were all internationally commended by a recent report from the US-based Health Effects Institute (HEI). The report examined over 700 peer-reviewed studies and included only those meeting rigorous scientific standards.

The HEI's criteria for inclusion required compensatory measures against 'confounding factors' – such as socio-economic background and smoking habits – which tend to skew results. However, the number of existing studies meeting these requirements is

relatively small, partly because studies of this form of air pollution have only recently become a research focus.

'This new problem of so many cars on the road, and particularly the modern diesel cars producing very, very small particles which can penetrate deep into our lungs, was not really appreciated until the 1990s,' says Professor Frank Kelly, a leading health expert with Kings College London. 'It's a modern type of air pollution issue that we're now having to deal with.'

Only 15 years have been spent on looking at this type of transport pollution as a public health challenge. For the big public health questions – the link between smoking and lung cancer, for example – assembling sufficient data to make authoritative statements takes a number of decades.

Given this limited amount of qualifying studies, the HEI report itself only offers one watertight finding: that exacerbation of existing asthma conditions is caused by high traffic exposure. Though a concern for many of the nation's five million asthmatics, this is not the new information that might motivate politicians to take broader action, and has been unofficially described by one of the report's authors as the 'tip of the iceberg'.

Experts say further analysis will confirm additional findings sooner rather than later, with heart disease the principle public health hazard.

Complications

Doing the science is not easy, however, and there are a number of complications to contend with. Trends of urbanisation and increased prosperity – which drives the greater uptake of personal motorised transport – are fairly universal in increasing exposure to traffic pollution. But the level and make-up of the pollutants faced by different populations vary substantially, as do the characteristics of the populations themselves.

Lab-based toxicology struggles to emulate these diverse conditions in any useful way. On the other hand, epidemiological studies that simply compare personal health with distance lived from a major road are deeply inadequate. For instance, much of an individual's daily exposure can come from the short periods of time spent in highly-polluted micro-environments, such as busy roads or underground metro systems.

A further complication is the selection of a surrogate (the measurable indicator for overall levels of traffic pollution). Elemental carbon, benzene and nitrogen oxide (NOx) are most common, but none are ideal as none are entirely

specific to traffic. They collectively account for over 40 per cent of all-source emissions.

Instead the better studies as selected by the HEI report use a hybrid approach incorporating additional data such as land-use models, questionnaires on personal activity, information on weather patterns, micro-monitoring of a wide range of pollutants and some toxicological work. This causes comprehensive studies to be expensive, and therefore few are undertaken.

What next?

The question really is what to do with the emerging findings, and how to use them to improve matters.

Statistics are frequently employed. The recent figure of 51,500 premature deaths per year in the UK alone, from the European Topic Centre on Air and Climate Change, has been widely cited by the media. It was seized upon by the parliamentary committee report last month to emphasise Government failings.

This statistic conveys the severity of recent research findings, and is based on a broadly accepted (if crude) coefficient for estimating mortality using concentration of particulate matter (an increase in mortality rates of 6 per cent for each extra 10µg of PM 2.5 per cubic metre of air). However, it also uses an unusual high-resolution modelling approach, and should be recognised as a top-end estimate.

Efforts to highlight air pollution's costs in both monetary and human life terms must contend with such ambiguities. But they certainly have their place. For instance, the parliamentary report in March also drew on Institute of Occupational Medicine research to describe a hypothetical seven to eight month gain in average UK life expectancy if all airborne particulate matter were to be eliminated. This was compared with 1-3 month and 2-3 month gains through eliminating traffic accidents and passive smoking respectively (the ranges represent the smaller impacts these would have on women).

It is true that the models used to calculate these figures are not directly comparable, and that confounding factors remain. But it is also the case that the seven to eight month average conceals a much higher figure of around nine years lost by particularly exposed or sensitive individuals. It also ignores the non-mortality health benefits eliminating particulate matter would deliver.

Science rarely deals in absolutes, and it is of course important that inevitable complexities are both visible and accounted for. But while our understanding increases, any certainty of gauging air pollution's full impact on public health remains years away. It would be a dangerous game to wait so long before taking action.

Andrew Marszal is a freelance journalist

'This new problem of so many cars on the road - especially diesels - was not appreciated until the 1990s'

Wind energy finally seems to be moving somewhere in the UK, but without some new techniques, our grid is simply not going to cope with this flood of new green power. By **David Strahan**

Can our electricity grid cope with all the new wind power?

Earlier this year the Government awarded licences to build 32GW of offshore wind capacity, enough to provide a quarter of our yearly electricity, more than any other country has yet achieved, by 2020. Some analysts claim it can't be done, and the very attempt will threaten our security of supply. But luckily several European countries are way ahead of us and pioneering a range of approaches could eventually lead to a totally renewable electricity supply.

One of the most ambitious is Spain, where wind capacity has soared in recent years under a system of generous feed-in tariffs. Capacity stands at 19GW today, generating around 14 per cent of the country's electricity in 2009, and once – on a windy Sunday night last November – briefly delivering 54 per cent of its power. Yet the Spanish government wants to go much further and has set a target of 29GW by 2016.

For a country so determined to grow its wind capacity, it is ironic that Spain has

discovered one of the most important factors is the ability to shut wind farms down, or at least reduce their output from time to time. To achieve this, the Spanish grid operator REE (Red Eléctrica de España) has built the world's first renewable generation control centre, the Centro de Control para el Régimen Especial, or CECRE, housed in an anonymous concrete campus in the shadow of Madrid's Barajas airport. According to Miguel de la Torre, the REE official who shows me round, CECRE has been crucial to Spain's success in incorporating so much wind power so far and to its future plans.

With great power...

Controlling the power output of wind farms is important for keeping the system within its safety margins when the wind is blowing strongly and demand is low, and all the more so as wind capacity grows. Yet in Britain, the National Grid control room at Wokingham

cannot even measure the output of half the country's wind capacity, still less control it. By contrast technicians at CECRE receive live output data from every wind farm once every 12 seconds, displayed on a wall of huge screens and maps, which helps their colleagues in the main grid control room balance the variable wind output by raising and lowering the production from flexible generators such as gas fired plants.

Wind turbines have priority in the Spanish system, but sometimes output has to be curtailed, and CECRE can send signals back to the wind farms requiring them to trim production within 15 minutes if necessary. That's important because if they couldn't control wind output so quickly, REE would have to set production limits a day or more ahead on the basis of less reliable weather forecasts, and allow for a larger margin of error. The control offered by CECRE means they can run the system nearer to its limits, using more wind power overall.

'I look forward to when Scotland boils a kettle on African electricity'

A watery solution?

The ability to turn turbines down is all very well when there's more wind power than demand, but what about when the wind drops? Spain's answer is to ramp up production from fast-reacting gas fired power stations, and this could easily end up being the default position for Britain. But Portugal has come up with a more climate-friendly alternative: a massive expansion of hydro electricity.

Portugal already has a lot of wind and hydro, but most of its hydro is 'conventional', meaning the reservoirs are rain-fed and the water can only flow downhill once. To make the most of the wind-hydro partnership, the hydro should be 'pumped storage', where two reservoirs at different heights are connected by pipes and reversible water turbines. Then when the wind blows at night and demand is low, cheap electricity can be used to pump water uphill, and during the day when demand and prices are high, the water can rush back down to generate power. It takes more energy to pump the water up than is generated on the way down, but that's the price of storing energy so it can be used when needed, rather than when the wind chooses to blow.

Portugal plans to more than double its wind capacity from 3.5GW to 8GW by 2020. To help balance this it will also increase hydro from 5GW today, of which less than a fifth is pumped storage, to 9.5GW by 2020, when around half will be pumped storage. This will lift the renewable proportion of Portugal's electricity from 45 per cent today to 60 per cent in 2020, despite a big predicted rise in demand. 'We are very lucky,' admits José Medeiros Pinto, deputy director of planning for REN, Portugal's grid operator, 'if we didn't have hydro, hitting our renewables targets would be much more difficult and expensive.'

Britain is not quite so lucky. True, we do already have 1.4GW of conventional hydro and almost 3GW of pumped storage, at plants such as Dinorwig in Snowdonia, mostly built decades ago to mop up excess nuclear power during off-peak hours. But the potential to increase capacity is limited. Scottish & Southern recently announced plans to build another 900MW of pumped storage at Loch Lochy and Loch Ness, and it's estimated Britain could build another 2GW of conventional hydro. But that's not remotely enough to balance 32GW of wind.

Another way to balance wind is to trade it with your neighbours, which is how Denmark has coped with a huge increase in wind capacity in recent years, although this strategy is starting to creak. Because as well

as lots of turbines Denmark also has thousands of combined heat and power (CHP) plants, which are efficient but inflexible. The plants provide district heating and electricity from the same equipment, so if you need the heat you get electricity too, but if the wind is blowing and demand is low, the result is often too much power. The solution so far has been to export excess electricity through interconnectors to Germany and Norway when the wind blows, and import when it doesn't.

But Denmark will not be able to rely solely on international trade to balance its grid as it pursues ambitious plans to double its wind capacity by 2025 and generate half its annual electricity from wind. That's because a huge increase in wind farms is also planned in Germany and Norway, so when the wind blows in future, the neighbours won't be able to absorb the excess power from Denmark. The Danes know they have to find ways to balance the grid within their own borders.

The problem is not trivial. Already wind generation occasionally exceeds total demand in off-peak hours, and with twice the capacity it would often exceed even peak demand. Network operator Energinet has launched an industry-wide project to develop an 'EcoGrid', where wind power is balanced not only by other forms of electricity supply but also through demand management – shifting consumption to suit supply, rather than the other way around. In an initial report, EcoGrid researchers found that while Denmark's CHP is part of the problem, it may also offer part of the solution. CHP plants come equipped with hot water storage tanks, and these could be fitted with electrical heaters to soak up excess wind power and save it to be used later as heat. The next step would be to install hundreds of thousands of ground source heat pumps in houses and buildings across the country, which would perform the same role but with greater capacity.

Smartening up the grid

While demand management is clearly vital, it is not much help for the biggest problem of all: when the wind fails to blow for days or even weeks, as during the big freeze in January. Even countries that are way ahead in wind balancing like Spain and Portugal continue to rely on fossil generation to fill this gap. Kjeld Norregaard of the Danish Technology Institute (DTI) freely admits that so far, 'we have only solved a fraction of the problem.'

In Britain, where power demand ranges between about 20GW and 60GW depending on season and time of day, the National Grid

estimates the potential 'flexible demand' could amount to 12GW by 2020. But that assumes a fleet of one million electric cars that could be charged on excess electricity, and the company thinks under 8GW is more realistic. Much will depend on smartening the grid, yet the Government's deadline for the installation of smart meters in every home – a basic building block – is ten years away. So how will Britain crack it? Conventional thinking suggests in the short term we will follow the pack. In one planning scenario, 'Gone Green', which National Grid describes as 'plausible but extremely challenging', 28GW of wind in 2020 is combined with 12GW of new gas fired power and three each of nuclear and coal – perhaps with carbon capture. But an alternative, entirely renewable solution is beginning to take shape far more quickly than anyone could have anticipated.

Beyond the national grid

Two years ago the idea of a continent-wide supergrid seemed science fictional, but today elements are suddenly falling into place. Last December eleven North Sea countries signed a memorandum of understanding to establish a super-efficient high voltage direct current (HVDC) sub-sea grid, largely to trade the output of planned offshore windfarms. Officials from energy ministries, regulators, utilities and the European Commission met in Brussels in February and March and are preparing a detailed action plan to be signed off by the end of the year. In a separate development, ten major power engineering companies – including giants such as Siemens and Areva – launched the Friends of the Supergrid (FOSG) to demonstrate industry confidence that this massive infrastructure project is achievable.

The supergrid would solve the 'Danish problem' of reliance on trading power with your immediate neighbours because the distances involved are so much greater and encompass different weather systems. With electricity trunk routes stretching from Ireland to Kazakstan, and Scandinavia to Morocco, the wind would always be blowing somewhere, and there would always be demand for that power somewhere else. 'I look forward to the day when Scotland turns on the kettle to be powered by North African electricity,' said John Sturman of Parsons Brinckerhoff, the engineering consultancy at the FOSG launch in London in March. With so many different wind farms – and solar and hydro plants – feeding into the grid, the variations in output would even out to create a far more dependable supply. Renewables would be balanced not by fossil plants, but by each other.

*David Strahan is an energy writer and author of *The Last Oil Shock**



What would banks do in a green economy? Banks. Love 'em or hate 'em, they're an integral part of nearly every economic system. But just how would they function in a truly green economy, asks **Molly Scott Cato**

Allowing Adair Turner to create the post-crisis regulatory framework for our banking sector would seem to be a clear example of leaving a gambling addict in charge of the casino. He has been a non-executive director at Standard Chartered Bank and Vice-Chairman of Merrill Lynch Europe, and boss of the lobby group for UK corporations, the Confederation of British Industry. In the turmoil of autumn 2008 he was brought in to lend weight to the Financial Services Authority, which had demonstrated its utter ineptitude at ensuring standards of probity and had played its own part in destroying the credibility of the banking sector.

I feel the need to establish his track-record before saying that many of the proposals in Lord Turner's review of the banking sector are rather good ones. He proposes, along with many greens, that government should take more control over the banking industry, both domestically and internationally, to ensure that social benefit is achieved, not just private profit. He does not, as we green economists do, argue that credit should be channelled towards sectors most likely to facilitate the move towards a low-carbon economy, but he does argue that governments should influence decisions about who is able to borrow the limited amount of money banks are now making available.

Beyond Turner...

Green monetary policy would be designed to move us towards a sustainable economy. This means reining in the uncontrolled creation of money to fund speculative transactions and its redirection towards investment in our low-carbon future. It would mean, as implied by the Turner Review, the retaking of political power over the financial corporations which was given up at the time of Big Bang in 1986. Strict controls on financial instruments would permit only those that are transparent, that offer limited risk of financial destabilisation and are clearly beneficial to society at large.

Turner's proposals are a good start, but green economists have a more radical vision of how a money system should operate: what would be the role of banks in such a vision? The commercial banks' pursuit of interest poses a challenge for the green economist because, within a steady-state economy, it seems fairly certain that interest rates will be fixed at 0 per cent. Interest represents the accrual of extra value, and that value has to come from somewhere. Where it comes from at present is the body of our poor old mother earth. Perhaps we could squeeze some marginal extra value from the economy via greater human ingenuity or higher energy efficiency, but once the economy is in equilibrium with the planet, interest will be only a memory.

Interest-free loans

So can we imagine a bank that functioned without interest? In fact we don't have to because that bank already exists and is found, unsurprisingly, in Sweden. Rather than paying interest on their loans, borrowers pay after-savings (to keep the bank well capitalised) and when they have repaid the principal this is returned to them as a lump sum. The fact that this enforced saving accrues an amount of money more or less equivalent to the sum they originally borrowed indicates the iniquity of the interest banking model, where that money would have been claimed in interest and redirected to the bank's shareholders.

As the Channel 4 debate between the Chancellors amply demonstrated, these fundamental questions about money and banking are not part of the public debate. All three refuse to question the instability and unsustainability of the capitalist system. All three refuse to countenance debate about whether it was right to give billions to the banks, when that is the direct cause of worse-than-Thatcher spending cuts. Rather than shuffling the deckchairs on the Titanic, they are shuffling the pack of cards in the global casino. The clamour for justice, both environmental and social, does not penetrate its walls.

Molly Scott-Cato is a reader in Green Economics at the Cardiff School of Management, author of 'Green Economics (Earthscan, 2008) and a regular columnist for the Ecologist

'Can we imagine a bank that functions without interest? We don't have to — it already exists'

