

The race to replace fossil fuels and find ways to reduce their impact

Climate change & technology

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Can clean coal and white rooftops help a power-hungry planet?

Carbon capture is all the rage, but a change in consumption is the long-term solution

John Vidal

In the next 35 years, says the International Energy Agency, the world will have to spend about \$45tn on new power stations to keep up with growing global demand for electricity – or to just replace the worn-out ones. If companies and governments build coal power stations, which are by far the cheapest and easiest to operate, then there is no chance of holding, let alone reducing, carbon dioxide emissions. Catastrophic climate change will inevitably follow.

There are two broad ways to address the problem. One is for the world to simply forgo coal. Britain, China, the US and other big coal users could voluntarily agree to leave the dirtiest of all fossil fuels in the ground and turn to renewable energies, energy saving or nuclear power. Over a period of 30 years, governments and the public could wean themselves off fossil fuels and come to regard coal like cigarettes – a dangerous and stupid habit.

The other way is to find a technological fix. Here, engineers would devise a way to capture and store the carbon dioxide emissions from coal plants. The gas could be liquefied and then pumped deep underground into old oil and gas fields and left for millions of years. Over time every power station in the world would be retro-fitted with a carbon capture and storage kit (CCS) and every new plant would automatically be equipped. Result: in 30 years, 80% of greenhouse gas emissions from coal would be diverted from the atmosphere.

CCS sounds attractive and is actually just round the corner. The technology is proven in all its parts. All it needs is for governments or industry to commit a few billion dollars to have some full-scale demonstration plants set up to prove they can work on a grand scale. The UK government says that the first integrated clean-coal



Dirty power ... a worker prepares coal at the Chongqing Steel Company in China China Photos/Getty Images

power station could be up and running within five years. From then on, the technology could be rolled out around the world, it says.

Governments love big technological answers to big awkward scientific problems such as climate change. In the case of coal, voters, unions and companies would not have to be asked to change their behaviour if CCS was used. No jobs need be lost,

“Technology is important to improve efficiency, but we should not wait for it to be developed”



and the transition to CCS could take place gradually in the normal course of industrial evolution.

But going down the technological route alone raises many questions. What is barely mentioned with coal is that it would cost trillions to equip the world's 4,000 large coal-powered stations with CCS. It would take decades to put in place – by which time it would be too late to avoid catastrophic climate change. It would also burn up to 40% more energy just to remove the greenhouse gases; and a vast and fiercely expensive giant infrastructure of pipes and subsidiary plants would have to be built.

Clean coal is just one of an array of emerging technological solutions to environmental problems. As tackling climate change and degradation becomes more pressing, so the clamour for big, quick answers is growing. In the past five years there have been

serious suggestions to manipulate the global energy balance on a vast scale. Scientists at institutions from Nasa to UK universities are raising the possibility of cooling the planet directly through “geoengineering”.

The Nobel prize-winning scientist Paul Crutzen four years ago proposed releasing vast amounts of sulphurous debris into the atmosphere to create a haze to cool Earth and mimic the effect of the dust thrown up by massive volcanic eruption. Other scientists have suggested using mirrors to bounce sunlight back into space, fertilising the oceans with iron to amplify their ability to absorb carbon, or painting millions of roofs white to reflect solar rays.

Last week one of the world's leading atmospheric scientists, Wallace Broecker, challenged Greenpeace to consider sucking greenhouse gases out of the air and pumping them



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Can clean coal and white rooftops help the planet?

«Continued from page 1 into the deep oceans (Read both sides of the debate about this plan on page 4). Meanwhile, oceanographers have proposed dumping tonnes of iron into the Antarctic to stimulate plankton growth. Others suggest petrifying carbon dioxide, or even deflecting sunlight from the earth with a giant space mirror. Prizes worth millions of dollars are being offered for the most promising new technologies to address climate change.

Others argue against further tinkering with the earth's atmosphere. For a start, say Greenpeace and many scientists, technology can be very successful at addressing one problem, but often in doing so it creates others, which in turn will need more technologies to address them. Most large-scale geoengineering technologies are not only hard, if not impossible, to test, but may also have huge unintended and even irreversible consequences.

"Messing with the atmosphere is how we got into this mess in the first place," says Iain Watt, a climate campaigner with Forum for the Future. "I don't think we have a good enough understanding of how feedback systems work."

Other objectors argue that if we al-



Making waves . . . Portugal's 'sea snakes' harness the power of the ocean

low coal and fossil fuels to continue to be burned as they have been for the past 100 years, then we will hamper efforts to address the root problems.

"If people know that someone will bail them out of catastrophe, they are more likely to engage in risky behaviour," says one impassioned blogger on a technology site. "If we refuse to recognise the perils of pollution, nuclear proliferation, racial and religious intolerance, habitat destruction and overpopulation, we

will still be on a collision course with global disaster and the potential end of civilisation."

Some politicians share these sentiments. "If we remove responsibility from the individual we only postpone action later. Thinking there is always a miracle cure around the corner is not very sensible," says Caroline Lucas, a Green MEP. "Technology is important to improve efficiencies, but in the meantime we should not wait for it to be developed."

But what governments like most is that climate change may spawn a vast market for new technologies worth hundreds of billions a year, possibly underpinning the global economy for decades. As oil prices soar, renewable technologies become proportionately cheaper and more attractive.

Last year US venture capitalists alone invested \$2.5bn in solar and other clean green technologies, a 79% increase on 2006. The European investment bank quadrupled its support in 2007 for clean energy projects and major investments are being made in electric cars and batteries and solar and tidal technologies. Last year Gordon Brown estimated that the green technology market was already worth \$50bn a year and could be worth more than \$600bn in a decade.

But Lucas warns that technology alone will not get us out of the mess: "People reach for technical fixes when in reality we need behaviour change too. Governments are not happy to talk about consuming less. But the reality is that efficiency gains that come with better technology can be overtaken by consumption, or dwarfed by volume growth. At some point we just have to stop postponing real action."

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How the telecoms industry can be part of the solution

Today's world is an increasingly connected entity, as fibre-optic cable, wireless and satellite broadband stream voice and data to mobile phones, PCs and a host of devices. In societies that are "always switched on", this can contribute to the problems of climate change – and its solutions. The telecommunications industry has been putting its house in order by switching to more energy-efficient technology.

Next-generation networks are 40% more efficient and telecommunications companies are replacing old-fashioned exchanges with compact switching software, while modern data centres, banks of servers and microprocessors can be configured without costly high-energy demanding air conditioning.

Telecommunications companies have also been developing products and services aimed at helping businesses and individuals reduce their carbon footprint. E-commerce and online billing provide an alternative to physical shopping and mountains of paper, while online teleconferencing, one of the most important weapons in

reducing CO₂ emissions, is replacing the need for business travel.

Based in Geneva, the International Telecommunication Union, a UN agency, is responsible for promoting sustainable information and communications technologies and globally interoperable standards. ITU is a key part of UN Secretary General Ban Ki-Moon's vision to make business leaders and world governments aware that ICTs can play a major role in helping meet targets laid down by the UN convention on climate change and the Kyoto protocol.

ICTs can contribute to carbon reduction efforts through satellites positioned over the polar regions sending back signals that record critical variations in global warming, sensors that monitor industrial energy consumption, and sophisticated electronic controls that fine-tune car engines or run smart building management systems to optimise energy use.

ITU has this year run two major conferences, one in Kyoto in April and the other in London in June. Attended by telecommunications companies and government policymakers across its 191



IT technology is getting 'cleaner'

member states, the conferences aimed to develop targets that companies can work towards in reducing their greenhouse gas emissions. Malcolm Johnson, director of ITU's standardisation bureau, said: "If 20% of the European Union's communications were conducted by teleconferencing it would save 22.3m tonnes of CO₂ a year."

A joint study by the Climate Group

and GeSI, the global e-sustainability initiative, claims to have quantified for the first time the carbon emissions ICTs can save across all sectors of the economy. The report, published last week, Smart 2020: Enabling the Low Carbon Economy in the Information Age, concludes that by 2020 ICTs would reduce the carbon footprint of industries across the world by 7.8bn metric tonnes each year.

The Smart 2020 study was based on case studies from China, India and the US. In the US, the study found that smart building management systems and intelligent lighting controlled by sensors had the biggest impact on CO₂ reduction, while in India, where the electricity grid is set to double its carbon footprint, emissions could be reduced by switching power sources to micro-grids or local generation.

Luis Neves, chairman of GeSI and senior manager for corporate sustainability and citizenship for Deutsche Telekom, said: "We need to change people's mindset and behaviour. Our study found that there will be business opportunities and job creation in the low-carbon economy."

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Giant solar farm at heart of Portugal's green dream

A nation without oil or gas and no ambition for nuclear fuel is fostering a clean-tech revolution

John Vidal **Lisbon**
Ashley Seager

From a distance the bizarre structures sprouting from the high Alentejo plain in eastern Portugal resemble a field of mechanical sunflowers. Each of the 2,520 giant solar panels is the size of a house and they are as technically sophisticated as a car. Their reflective heads tilt to the sky at a permanent angle as they track the sun through 240 degrees every day.

The world's largest solar photovoltaic farm, generating electricity straight from sunlight, is taking shape near Moura, a small town in a thinly populated and impoverished region that boasts the most sunshine per square metre per year in Europe.

When fully commissioned later this year, the \$500m farm set on abandoned state-owned land will be twice the size of any other similar project in the world. It is expected to supply 45MW of electricity each year, enough to power 30,000 homes.

Portugal, without its own oil, coal or gas and with no expertise in nuclear power, is pitching to lead Europe's clean-tech revolution with some of the most ambitious targets and timetables for renewables. Its intention, says the economics minister, Manuel Pinho, is to wean itself off oil and within a decade set up a low-carbon economy.

"What seemed extravagant in 2004



Sun trap... the world's largest solar power farm takes shape Teri Pengilly

when we decided to go for renewables now seems to have been a very good decision," Pinho says. He expects Portugal to generate 31% of all its energy from clean sources by 2020. This means lifting its renewable electricity share from 20% in 2005 to 60% in 2020, compared with Britain's target of 15% of all energy by 2020. Having passed its target for 2010, it could soon top the EU renewables league.

In less than three years, Portugal has trebled its hydropower capacity and quadrupled its wind power, and is investing in flagship wave and photovoltaic plants. Encouraged by long-term guarantees of prices by the state, and not delayed by planning laws or government indecision, it has proved a success. Companies are expected to invest \$20bn in renewables by 2012 and up to \$200bn by 2020.

However, Portugal says it wants to develop a renewables industry to rival Denmark or Japan. When the government invited companies for tenders to supply wind, solar and wave power, it demanded they work with manufacturing companies to establish clusters of industries. This is a great success, say regional governments.

In northern Portugal, where the world's biggest wind farm, with more than 130 turbines, is now being strung across the mountainous Spanish border, a German company employs more than 1,200 people building 600 40-metre glass fibre wind turbine blades a year.

But it is Portuguese plans for wave power that are prompting the most interest in Europe. The world's first commercial wave farm is being assembled near Porto. Three "sea snakes",

developed by the Edinburgh-based company Pelamis, will shortly be towed out to sea and will start pumping modest amounts of electricity into the grid later this year.

It is a growth in renewables that is being followed across much of continental Europe. Soaring oil prices have led to such a boom for solar power that the industry could operate without subsidies in just a few years, according to industry leaders. At the solar industry trade fair in Munich this month there was growing confidence that the holy grail known as "grid parity" – whereby electricity from the sun can be produced as cheaply as it can be bought from the grid – is now just a few years away.

Solar photovoltaics (PV), which convert sunlight into electrical power, have long been dismissed as too expensive to make a meaningful contribution to the battle against climate change. But costs are falling as PV production booms, and with electricity prices rising rapidly in line with soaring oil and gas prices, demand for solar panels is increasing sharply.

"High oil prices have boosted demand even more. The market will probably expand another 40% this year," said Carsten Körnig, of the German solar industry association, referring to both PV and solar thermal systems, which produce hot water. He said that his previous assumption – that grid parity would be reached in Germany in five to seven years – now looked very conservative, since it allowed for only a 3% rise in electricity prices each year. In many countries increases of 20% a year are becoming the norm.

The man who sees endless possibilities

Kate Connolly

Hermann Scheer has been described both as the "solar king" and the "Stalin of wind power", but the German MP behind the revolutionary project to make his country completely energy self-sufficient is sanguine. "Our dependence on fossil fuels amounts to global pyromania," he says.

Scheer (right), the chairman of the World Council for Renewable Energy, has been a fierce advocate of renewables for more than 20 years. He came up with the idea of the "feed-in tariff law", which has been picked up across Europe and by opposition parties in Britain. According to what has become known as "Scheer's law", German households and businesses that generate renewable energy can sell it

back to the grid at more than triple the market price.

"The key to it working is that consumers have guaranteed access to the grid at guaranteed prices," says Scheer.

This probably goes further than any single piece of national legislation in the world to encourage the growth of the renewable energy industry. Power companies do not like it, but it has given incredible verve to an industry that had not, until now, had many believers.

More than 300,000 individuals and small businesses have jumped at the opportunity in Germany. Scheer's family, whose house is powered by a windmill, is among them. So far, 15% of

Germany's energy comes from renewable sources, a rise of 11% in just eight years. By 2030, the 100% target should have been reached. Both wind and solar sectors are growing at about 30% a year, making them attractive for investors and developers of technology. The potential returns are huge.

Several Mediterranean countries – including Spain, Italy and Portugal – have latched on to Scheer's law and are in the process of introducing it. The governments of Brazil and China have also asked Scheer to advise them on its application.

While Britain is under pressure to adopt something similar, Scheer can feel the strong re-

sistance to his ideas in a government that appears to be more wedded to nuclear power and coal. He calls the British government's attitude towards renewables "small-minded" and "inexplicable".

Scheer, a self-described "possibilist", would like to reverse the view in Britain, which he refers to as "the unbroken power of one-dimensional thinking", by demonstrating how free and plentiful renewables are compared with fossil fuels and nuclear.

"The amount of sun, wind, geothermal and bioenergy at our disposal is by far sufficient," he says. "Take just the sun – it sends around 15,000 times more energy to our planet than all 6 billion people need. These resources are indefinite and cheap – the sun and wind won't be sending you a bill."



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Test underwater CO₂ storage now...

A leading climate scientist challenges Greenpeace policy

Wallace S Broecker

Most of us who are concerned about global warming agree that an important part of any strategy to stem the build-up of greenhouse gases in the atmosphere will be to capture and store CO₂. Potential storage sites include spent oil fields, saline aquifers, layered basalts and the deep ocean.

While Greenpeace accepts the inevitability that CO₂ will be captured and stored, it strongly opposes storage in the deep sea. As it is clear that almost all the CO₂ released to the atmosphere by fossil-fuel burning will find its way to the deep sea, its objection is focused on the "point pollution" created by purposeful injections of CO₂. The fear is that such an activity will put at risk benthic biota – the community of creatures and plants in the deep sea – living near injection sites.

In February 2007, I contacted Bill Hare, a senior scientist at Greenpeace, asking him to reconsider its stance against experiments to evaluate the environmental consequences of CO₂ injected into the deep sea. I pointed out that if marine disposal proves to be economically favourable, forces more powerful than Greenpeace will inter-

vene and deep-sea disposal will commence without adequate testing and evaluation. Hare agreed to reconsider this matter in consultation with members of his and other organisations. In June 2007, he reported back that no change in policy would be made.

As a scientist, I seek rational decisions. So let me begin by outlining what is known about deep-ocean storage. To ensure that the injected CO₂ has adequate time to mix throughout the deep sea, injection should be at depths greater than 3,500 metres, the depth below which "liquid" CO₂ becomes more dense than sea water.

Experiments not only confirm that this is the case but also demonstrate that the CO₂ injected rapidly reacts with sea water to form a solid clathrate, which is more dense than both liquid CO₂ and sea water. The injected CO₂ would end up on the sea floor as a slush. This would gradually dissolve, releasing the CO₂ to the surrounding sea water, where it would react with the dissolved carbonate and borate ions to become chemically bound in the form of bicarbonate ions. As the concentration of carbonate and borate ions is small, the neutralisation would take place gradually as the CO₂-rich sea water mixed into the surroundings.

We know that the residence time of water in the abyssal Atlantic is 200 years, in the Indian Ocean about 800 years, and in the Pacific about 1,000 years. As the deep Pacific has the larg-



Will they be damaged by dumping? ... Australia's Great Barrier Reef corals

est volume, and is adjacent to earthquake-prone land areas where below-ground storage would not be safe, it will be a prime target for storage.

A conservative upper limit on the storage capacity of the deep Pacific would be to require that the CO₂ concentration in the water returning to the surface not be allowed to exceed the concentration in cold surface water at equilibrium with the atmosphere. Were this adopted, then the capacity of water deeper than 1,500 metres in the Pacific would be about 480 gigatons of CO₂, or about 130 gigatons of carbon for each 100 parts per million rise in atmospheric CO₂ content.

We know enough to say with confidence that deep-ocean disposal of CO₂ is feasible, but unless small-scale pilot experiments are conducted, information necessary to assess the impact will remain obscure. The injections could be made from ships equipped for deep-sea drilling, and if the CO₂ were

tagged with radiocarbon, its dispersal away from the sea-floor clathrate pile could be sensitively monitored.

Studies of the costs would also be conducted. The CO₂ would have to be sent through pipelines from its collection point to a port, where it would be loaded on tankers that would carry it to a floating ocean station, from which it would be piped to the abyss. Ocean disposal will become a viable option only if the costs are competitive with those associated with storage in hypersaline continental aquifers.

I sympathise with those who claim that the benthic world is a fragile one. Hence, before we poke it with CO₂, we should do our homework. Therefore, I challenge Greenpeace to allow a pilot project to proceed.

Wallace S Broecker is the Newberry professor in the department of earth and environmental sciences at Columbia University, US

... No. Dumping CO₂ in the deep ocean isn't the real solution

Bill Hare

A careful, rational and scientific analysis of the option of CO₂ disposal in the ocean leads to the conclusion that it is not viable. Deep-water injection CO₂ would cause potentially irrevocable damage to those deep-water ecosystems directly affected and at scale would result in far more widespread effects in the abyssal zone over time as the clathrates dissolve. Over far longer timescales it would result in changes to abyssal ecosystems that feed back to the global carbon cycle.

To suggest that there is no indication that the projected rise in upper ocean CO₂ content will have adverse impacts on fish and, on this basis, to argue that the spread of CO₂ through the deep sea would therefore also be benign, is misleading and ignores the growing evidence that projected

rises in upper ocean CO₂ and consequent acidification are likely to have profound impacts on calcification rates and calcifying organisms. It is predicted that upper ocean pH levels will drop lower than those recorded at any time over tens of millions of years, and at a rate greater than any previous change. There is also evidence that deep-water crustacean species, sediment-dwelling organisms and associated ecosystem processes could be adversely affected.

The fact that deep-water CO₂ concentrations are currently lower than those of surface waters should not be taken as an indication of a vast unexploited capacity for CO₂ disposal. Our knowledge of the biogeochemical processes that have contributed to the current distribution of CO₂ in the deep oceans remains limited, as does our capacity therefore to predict the

consequences of multibillion-tonne injections of CO₂ at depth.

Wallace Broecker argues that a series of experiments involving the release of one tonne quantities of CO₂ at depths greater than 3,500 metres are the next logical step. One-tonne release experiments to observe behaviour and determine impacts is one thing, but experiments intended as proof of the concept for multi-gigatonne injections in the future is quite another. An obvious critical aspect is the potential for cumulative impacts resulting from continuous injections over long periods, or a large number of injections. The nature and likelihood of these cumulative impacts could not be assessed from the results of the experiments he suggests.

Existing dumping laws are designed to protect the marine environment from irresponsible and unsustainable

waste-disposal operations. By definition, injection of CO₂ at the seabed deliberately and immediately relinquishes any control over the waste. Such disposal operations are irreversible. If the models Broecker suggests we should rely on prove inadequate or inaccurate, what do we do?

Ocean disposal of CO₂ draws attention away from the real solution: there is no alternative but to drastically reduce emissions. Many in the scientific community and in environmental groups share Broecker's frustration at the lack of action to date and his great sense of foreboding over the fate of the planet if we do not succeed in getting emissions reduced quickly. But in this case we must agree to disagree.

Bill Hare is a visiting scientist at the Potsdam Institute for Climate Impact Research, Germany

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Forest protection fund targets Congo basin

Africans are offered an alternative to logging and subsistence farms

Julian Borger

The biggest ever fund set up to battle deforestation has been launched this month, targeting the vast Congo basin rainforest in central Africa. Britain and Norway are providing \$216m and will also supply satellite imaging technology to monitor the area.

The fund is intended to provide African governments and people living in the rainforest with a viable alternative to logging, mining and felling trees for firewood and subsistence farming.

The Congo basin rainforest is the world's biggest after the Amazon, at about twice the size of France, but is rapidly dwindling. It is being cut down at the rate of 25,000 football pitches a week, accounting for 18% of annual carbon dioxide emissions.

Projects will be eligible for funds if they can demonstrate that they will

curb the destruction of forest by providing alternative sources of income or energy, for example. Their effectiveness will be monitored by high-definition cameras made in the UK due to be mounted on satellites. "We are pledging to work together to secure the future of one of the world's last remaining ancient forests," Gordon Brown said at the scheme's launch. Britain initiated the fund and is providing \$116m.

Jens Stoltenberg, the Norwegian prime minister, whose government is putting \$100m into the scheme, said that the money spent was the most immediate and cost-effective way to combat greenhouse gas emissions. "By doing something about deforestation we can achieve a big and rapid reduction in emissions," said Stoltenberg.

The estimated cost of reducing emissions by halting deforestation is \$6 per metric tonne of CO₂, compared with \$100-200 a tonne for carbon-capture schemes.

British and Norwegian officials acknowledge that the biggest challenge will be ensuring that the money is ef-



Let's keep it green . . . fund aims to battle Congo deforestation Alamy

fectively spent. The Congo rainforest sprawls across Cameroon, the Central African Republic, the Democratic Republic of the Congo, Equatorial Guinea, Gabon and Congo-Brazzaville. Across large swaths, corruption is rife and mining and logging companies are prepared to offer large rewards to

communities and regional authorities to open up their forests.

"Everyone knows how not to cut down a tree," Stoltenberg said. "The big challenge is the institutions, the framework, the monitoring and the control. I don't believe that is easy but that cannot prevent us from trying."

The Congo Basin Forest Fund will be co-chaired by Wangari Maathai, a Kenyan activist and Nobel Peace laureate, and Paul Martin, a former Canadian prime minister. Maathai said that the fund entered industrialised countries into partnerships with those suffering the effects of warming. "Africa has to make very tough choices and she has to feed herself. But it's very important we do not sacrifice indigenous forests for biofuels or any other alternatives."

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Changing continent

Marion Cheatele, of the UN, talks about the recently launched environmental atlas of Africa

guardianweekly.co.uk/fragileplanet

The world's had a wake-up call



ITU is answering it

Climate change is a serious problem. So at ITU, we're looking at serious solutions. For instance, by using information and communication technologies (ICTs) to monitor global climate change. Or by working with other industries to reduce greenhouse gas emissions through the innovative use of ICTs. And, of course, by promoting and adopting a carbon neutral approach within our own industry. Through leadership and example, we want to show that the climate is not the only thing that can change.

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