

Technology and the environment

Tunza Conference

Capturing carbon

Perennial dilemma

Greener cleaners

Virgin Earth



Small is controversial

Designing the future



TUNZA

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for Youth. To view current
and past issues of this
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**Partners for Youth
and the Environment**



UNEP and Bayer, the German-based international enterprise involved in health care, crop science and materials science, are working together to strengthen young people's environmental awareness and engage children and youth in environmental issues worldwide.

The partnership agreement, renewed to run through 2010, lays down a basis for UNEP and Bayer to enlarge their longstanding collaboration to bring successful initiatives to

countries around the world and develop new youth programmes. Projects include: TUNZA Magazine, the International Children's Painting Competition on the Environment, the Bayer Young Environmental Envoy in Partnership with UNEP, the UNEP Tunza International Youth/Children's Conference, youth environmental networks in Asia Pacific, Africa and Latin America, the Asia-Pacific Eco-Minds forum and a photo competition, 'Ecology in Focus', in Eastern Europe.



Cool & Cooler



COOL: Wildlife-watching: birds, bears, dolphins, butterflies...



COOLER: Getting involved in wildlife surveys. Contact your local council, or national or regional environmental organization, find out what surveys are taking place in your area, and volunteer to help.



COOL: Energy-saving escalators. Escalators and moving sidewalks are handy. But continuously running motors consume enormous amounts of energy. Automatic stop/start escalators stop moving when they sense no one is using them, and turn on only when approaching riders walk through a barrier linked to a power switch. Some escalators and people movers are configured to use less energy by moving slowly when carrying a lighter load, and speeding up when more people step on.



COOLER: Taking the stairs – while helping that little old lady with her bags.



COOL: Clothes made of hemp.



COOLER: Surgical gowns made of bamboo. Bamboo contains a substance that kills bacteria, so researchers in Coimbatore, India, have used its fibre to make a highly absorbent garment that reduces the risk of infection during surgery.



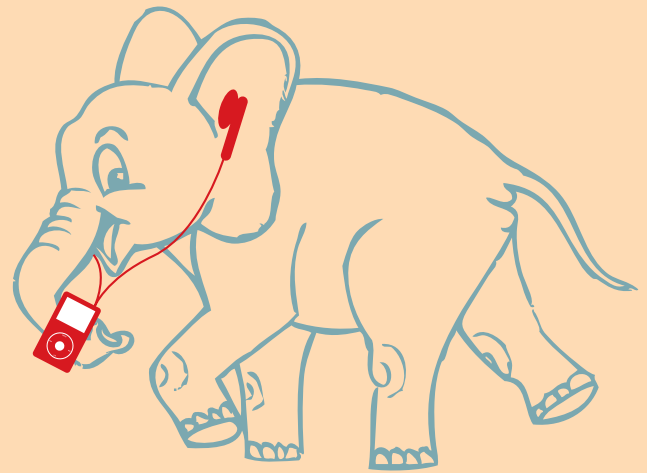
COOL: Recycled rubber tyre swings. Eco-nostalgia: be a kid again, spinning under a tree.



COOLER: Recycled rubber tyre sandbags. Sandbags used to control erosion often disintegrate. Recycled tyres are now providing a sturdier substitute, and using them – instead of dumping them – takes pressure off landfills. Eco-Blocks made from tyres can be interlocked, stacked, and glued or staked into place, and can be reused for up to 10 years.



COOLEST: Recycled rubber tyre houses. Earthships, the brainchild of Michael Reynolds of New Mexico's Solar Survival Architecture, are houses made of stacks of recycled tyres rammed with dirt, packed with mud and plastered with adobe or stucco. The company teaches people how to construct them, and offers demonstrations to officials in disaster-relief areas like Mexicali, Mexico, and La Paz, Bolivia.



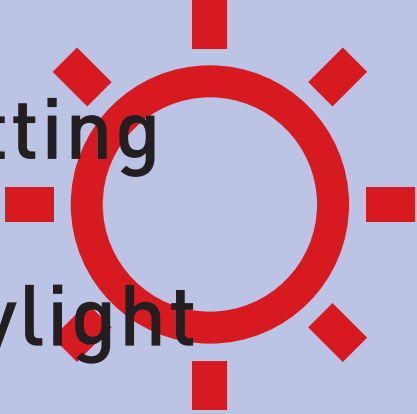
EDITORIAL

Technology is one of the things that separates humans from animals, and it has increasingly shaped our world. From earliest times, people have applied their knowledge to making tools and machines that serve their purposes – from the wheel to the computer. Some now laud technology as the foundation of all prosperity, and believe that few constraints should be put on its development. Others condemn it as the cause of massive environmental damage, and call for strict controls. But the truth is that it is both and neither. Technology has both helped bring wealth to much of the world, and been the instrument of much of the harm done to the planet and its life. But in itself it is neutral; its effects, for good or ill, are down to what we make of it.

As our scientific knowledge, and our ways of putting it to practical use, rapidly increase, we need to ask two questions. Technology for what? And technology for whom? Everything depends on the answers. It should be used for development, not destruction, it should benefit humanity as a whole rather than just the already wealthy few and, rather than be used to promote economic growth at all costs, it must continue to be underpinned by the vital services provided by a healthy planet.

One key is to ensure that technology is appropriate: empowering to the people that use it, suited to the places where it is applied, and – above all – designed to promote the sustainable development that eliminates poverty while safeguarding the Earth and its natural systems. Another is to ensure that it is widely shared, so that as many people as possible benefit from it. There are many cases where technology has fulfilled both these goals; more often, however, it is not even intended to do so. Our generation must redress the balance and concentrate resources and effort on developing technologies suited to our age, and to our fragile, interdependent world.

Letting in daylight



There's nothing like daylight – as those that are unfortunate enough to work at desks away from windows know too well. Overexposure to bright electric lights causes stress, whereas natural light can aid in relaxation. Producing electricity for lighting usually involves burning fossil fuels and emitting the carbon dioxide that causes global warming, but daylight is non-polluting and free.

Now a simple new technology, tubular skylights or solar pipes (as used at the clothes shop pictured right), brings natural light to interiors far from windows. It redirects sunlight through a clear plastic or glass dome fixed on a roof and sends it down a metal tube to the ceiling of the room to be lit. There, the concentrated light hits a lens or mirror that diffuses it, spreading out the daylight.

The tube was a big hit in Australia where it was first commercially produced in 1991, then spread to the United States of America, where it is used in schools and shopping malls. Today, solar tubes are being produced and used from Argentina to China, Guatemala to Japan, Mexico to Poland, Russia to the United Arab Emirates. The Food and Agriculture Organization of the United Nations has even considered using tubular skylights in developing countries to help micropropagation – starting plants in tissue culture, which increases the number of healthy seedlings.

The tubes can be installed easily, and are cheaper than solar cells. More advanced versions of them track the sun and can pull light down more than 100 metres.

Lighting accounts for up to 50 per cent of commercial energy consumption and up to 20 per cent of industrial consumption, so this emerging technology – besides improving well-being – could make a big cut in carbon dioxide emissions.

Written nearly 300 years ago, Swift's words remain a telling endorsement of the importance of technology. And the scientists that developed the seeds that made possible the famous Green Revolution of the late 1960s and early 1970s fully deserved the accolade. Wheat and corn bred at the International Maize and Wheat Improvement Centre, in Mexico, and rice developed at the International Rice Research Institute of the Philippines were two or three times more productive than traditional varieties. Harvests soared. India, long a byword for famine, quickly reached the brink of self-sufficiency in cereals and was able to provide massive food aid to the newly independent Bangladesh; for a while she came second only to the United States as a donor. Mexico, the other country to pioneer the new crops, exported a tenth of her harvest for five years.

And yet malnutrition initially remained widespread in both countries, and a United Nations report concluded that the miracle crops had done little to increase the amount of food their people ate because so many remained too poor to buy enough. In some ways the Green Revolution made the poverty worse. Small subsistence farmers could not afford to buy the expensive new seeds, or the fertilizers they needed to make them so productive, and ended up being pushed off their land in favour of richer farmers able to make use of the new technology. Modern machinery was brought in to cultivate the bigger fields, which meant that the newly landless poor could not even get work as farm labourers. The variety of crops grown diminished as monocultures took hold, and biodiversity suffered as traditional agricultural methods that were friendlier to wildlife disappeared.

Lessons were eventually learned and care was taken to integrate the new crops into existing agricultural systems. And in the long run they ended chronic famine and helped to halve malnutrition in South Asia over three decades. But the story shows both the upsides and downsides of technology. There was nothing wrong with the Green Revolution seeds: they had great advantages and brought enormous benefits. But, like other technologies, they were not silver bullets capable of solving all of humanity's problems, and, where used inappropriately, they could also do great harm.

Controversial technologies

Similar debates now surround a host of controversial new developments, including biofuels, nanotechnology, genetically modified crops, and automatic surveillance techniques. All could confer great benefits; all pose considerable risks. Everything depends on how – and for whose benefit – the technologies are used.

At the time that the Green Revolution was at its height, another famous book – *Small Is Beautiful* by E.F. Schumacher – was popularizing the concept of 'appropriate technology'. This means developing technologies that are suited to the environment, culture and economic situation in which they are used, so as to get the most benefit from them.

Appropriate technologies may be old or new, simple or high tech. People-powered pumps using cups tied to string,



Aconcio Studio

Technology can help...

'Whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind... than the whole race of politicians put together.'

*King of Brobdingnag,
in Jonathan Swift's classic satire Gulliver's Travels*



which anyone can repair, are turning out to be much more appropriate – and much better at providing local people in remote areas with clean, life-saving drinking water – than modern ones requiring costly parts, fuel and maintenance. Yet mobile phones are proving to be a godsend in providing communications and spurring development in the same areas, which are unreachable by landlines. By the same token, houses may be best made of simple, traditional local materials like rammed earth, but best lit by white LED lights powered by solar cells.

Renewable energy

Renewable sources of energy are increasingly proving to be appropriate technologies in both developed and developing countries. The sources of their power – the sun, wind or water – are distributed free by nature, allowing energy to be generated where it is needed. In developing countries, this makes it possible for people to have all the advantages brought by electricity even when they live far from the electricity grid. Where there are grids – as in developed countries or the cities of developing countries – the same free distribution enables families to generate their own electricity, feeding the surplus back into the general supply, thus reducing the need to build costly new power

stations. And, wherever they are used, the renewables emit no carbon dioxide, and so are important in combating global warming.

Yet, however appropriate technologies may be, they cannot be relied upon to solve problems in the absence of action by people and governments. The efficiency of car engines in the United States of America, for example, has increased steadily over the past two decades, but this saving has been entirely offset by increases in the weight, size, power and accessories of the vehicles, so they burn just as much fuel per kilometre – and contribute just as much to climate change – as before. This has happened because the price of petrol remained low, and because government standards for car-fuel economy were not increased.

In fact, firm action is often needed to bring about technological change in the first place. Necessity remains the mother of invention: increasing incentives and rising legal standards almost invariably bring new technologies to market, sometimes even bringing out inventions made long ago but not commercialized because of a wish to get the maximum value out of the existing technologies before taking a risk with something new.

Sweet solution

Christopher Columbus said he had 'never beheld so fair a thing' as the rainforests of Haiti when he reached the Americas. Today they are almost all gone, and the bare land is severely eroded. What remains is threatened by making charcoal, the country's main cooking fuel. Now students at the Massachusetts Institute of Technology have worked out how to make charcoal briquettes from sugar cane bagasse, an abundantly available waste from one of Haiti's main crops. Dried bagasse is carbonized in an oil-drum kiln, mixed with cassava porridge and pressed into briquettes. These burn better than wood and produce less indoor pollution, a major cause of disease and death in the developing world.



KVA Matix

Light clothing

High technology and traditional craft are combining to lighten the lives of Mexico's semi-nomadic Huichol people, who live in the Sierra Madre far from electricity grids. Women weave and sew high-brightness LEDs (light-emitting diodes) and flexible photovoltaic panels into textiles to make the Portable Light. They are then worn or hung outside to charge by day, storing enough energy to provide light for four hours of reading and writing after sunset. Such literal enlightenment is also being tried out by aboriginal people in Australia.



Permaculture Research Institute/pritlickr

Call of

Agriculture can use huge amounts of water for irrigation as well as fossil fuels to power machinery and create pesticides and fertilizers. And it clears land that could sustain many different species, replacing them with the few that feed us.

Permaculture – developed by Australian environmental scientist Bill Mollison and his student David Holmgren – aims to produce food with fewer inputs while improving the environment. A wildlife biologist, Mollison observed that natural systems like forests and wetlands are self-sufficient and interlinked, with their different components working together: insects, for example, pollinate plants and provide food for birds, whose droppings nourish the soil. Permaculture sets out to mimic natural ecosystems to create large yields in a

self-sustaining system of perennial agriculture involving a diversity of plant and animal species.

The idea is not new. Native Americans have long planted squash, maize and beans together: the beans climb the maize while fixing nitrogen to fertilize the soil; the squash covers the ground, discouraging weeds and retaining moisture. Similarly, contemporary Mayan forest gardens still grow many species of plants for food, timber and medicine, without ploughing and using only organic fertilizers.

The principle of permaculture is designed for application just about anywhere, from urban kitchen gardens to swampland or tropical rainforests. Says Mollison: 'Instead of "What can I demand this land to do?", anyone who asks instead "What does this land have to give me?" will naturally work in harmony with the Earth.'

Greener greenhouse

High in the Himalayas – where temperatures can fall to -40°C – people are growing a range of vegetables and medicinal plants in greenhouses all the year round without using any fuel to heat them. They do it by using passive solar greenhouses, oriented to capture the maximum amount of the sun's heat, instead of burning propane or other fuels. Heat is stored in rock, earth or water, and released when the temperatures outside fall. Some designs even collect rainwater for irrigating the crops.



Martin Hughes



the wild

'First you take stock of external factors like climate, topography, soil and water supply, then choose plants and animals highly suited to these. Then you make the highest possible number of functional connections between species. Each plant or animal should serve a number of functions, and should also interact with others.'

Mollison has spent the last three decades teaching and encouraging people to establish permaculture communities, encompassing eco-villages and sustainable housing: he himself lives in one he founded in Tasmania.

And it's not just for richer countries. UNHCR, the United Nations refugee agency, has adopted permaculture principles to make the most of scarce land and water resources to help refugees attain self-sufficiency in Zimbabwe, and has used them to rebuild villages in war-torn Iraq.

Perhaps they have been most widely applied in Cuba. After the Soviet Union broke up, the country could not get enough oil to sustain its industrial agriculture. In 1993, its Government gave a grant to Australian permaculture consultants to establish a demonstration project in the capital, Havana, and to carry out training. People began growing food – bananas, pumpkins, grapes and more – in gardens on rooftops and patios as well as in car parks. Today, Havana grows 50 per cent of its own vegetables, while in other Cuban cities and towns, between 80 and 100 per cent of produce is grown locally.

'I like to call permaculture a "humane technology" because it deals in a very basic way with simple, living elements,' says Mollison. 'It doesn't involve complicated technology; it's a biotechnology which people, as living beings, can intuitively handle.'

Loans for phones

Mobile phones – and an innovative way of using them – are connecting remote communities in developing countries with the rest of the world for the first time. The Grameen Village Phone programme is bypassing the need for phone lines by setting up mobile phone businesses, giving villagers, mainly women, loans to buy a phone. The new entrepreneurs rent the phone out on an affordable call-by-call basis. Villagers can reach medical services, keep in touch with friends and family and even run businesses. And the operators earn profits to repay the loans and pull themselves out of poverty. Launched in Bangladesh in the late 1990s, the idea has spread to Cameroon, Rwanda, Senegal and Uganda.



Jeeves Sinclair/Flickr



Rolling hippos

Fetching water is an arduous, interminable, back-breaking daily task for women and children all over the developing world. They may have to trek for six hours or more a day, carrying 20-litre containers on their heads. The Hippo Water Roller replaces these containers with polythene barrels with steel handles, which are easy enough even for children and old people to push or pull over rough terrain. And since the Hippos can hold 90 litres of water each, they reduce more than fourfold the number of treks needed.

Water power

Some 45,000 African subsistence farmers have increased their incomes up to 10 times through simple foot-powered pumps. The pumps, which provide water for small-scale irrigation, were invented by a non-profit organization KickStart, and are now in use in Kenya, Mali and Tanzania, helping to grow high-value vegetable crops on small plots. The early designs pulled water from as deep as 7 metres; later versions can also push water uphill, making it possible to irrigate a slope from a stream or other water source at the bottom of a slope.

TUNZA answers your QUESTIONS

Q & A

1-2-3-4-5-6

Q How can technology best be harnessed in the service of people and the planet?

A The challenge is to harness technology so that we at least maintain standards of living in the developed world and improve those in the developing world while reducing our impact on the natural environment. That will probably involve accelerating innovation by investing a lot more in research and development (R&D). We need new institutions, visionaries, inventors and engineers, and we need to encourage more young people to become involved in and excited by science and technology. Environmentally sustainable technological R&D has to be seen as a public good if we are to begin harnessing new technologies in the service of people and the planet.

Q Is developing technology all we need to do to solve problems like global warming?

A Of course not, though technological developments – from harnessing wind, wave and solar power to carbon capture and storage – will certainly help. Fundamentally we have to change attitudes and evolve patterns of behaviour that provide stewardship for the planet. This particularly includes changing our patterns of consumption to reduce our impact on the Earth.

Q What are the most promising technologies available today? And what are the best ones likely to be developed in the near future?

A Be on the lookout for industrial-scale use of solar photovoltaics, solar thermal power stations, second-generation biofuels, deep-sea turbines and wave or wind parks. Further ahead, nanotechnology, developed with great care, could open up new possibilities. But though new technologies are critical to the future, many are not yet affordable or cost-effective. That's where R&D comes in.

Q What will we do when the oil runs out?

A For the foreseeable future, like it or not, oil will continue to be the major energy source for transport, and – alongside

coal – for generating electricity. This poses two immense problems. First, though it will not run out anytime soon, oil is expected to get increasingly scarce, with production peaking in the next decades, putting an end to the cheap supplies that have powered industrial civilization. And second, burning it causes global warming, and there is still enough oil in the ground to destroy the atmosphere. We must tackle both problems by using it more efficiently – wasting less and consuming more sustainably – and by vastly increasing our efforts to develop renewable, non-polluting sources of energy.

Q We hear that 'waste is a resource we haven't yet found a use for...'. Can you explain?

A Wastes, by definition, are products we don't value. But many wastes, including ones currently considered hazardous, can be recovered, recycled and reused. For example, biodigesters can convert animal and human sewage into methane that can be used as a fuel for cooking and heating, and even for generating electricity, while the second generation of biofuels may well be developed from waste products such as sawdust and straw.

Q How do we make technology our servant rather than our master?

A There is no substitute for human intelligence and its transformational power. The challenge lies in striking a balance between common sense and innovation. This involves widespread acceptance by science, industry and consumers of the precautionary principle. The principle – enshrined in such traditional wisdom as 'better safe than sorry' or 'an ounce of prevention is worth a pound of cure' – provides for preventative action to be taken where there is good evidence that something may cause irreversible damage to people or the environment, even if there is no absolute proof of this. The principle has been attacked for impeding progress but, properly applied, it can boost safe technologies while minimizing the kind of damage that has been done heedlessly, for example to the Earth's ozone layer and climate.



Do you have any QUESTIONS on environmental issues that you would like the experts at UNEP to answer?

Please send them to unepub@unep.org, and we will try to answer them in future issues.

small is **CONTROVERSIAL**

Getting your head around something 80,000 times smaller than the width of a human hair is demanding enough. Now imagine trying to manipulate and control it.

The rapidly developing science of nanotechnology ('nano' is Greek for 'dwarf') harnesses and engineers the unimaginably small. A million nanoparticles would fit comfortably on the head of a pin. If one were expanded to the size of the full stop at the end of this sentence, the letter 'h' next to it would be nearly a kilometre high.

Dealing with such tiny particles requires extreme mechanical precision, on a scale infinitely smaller than anything ever attempted before, and is only now possible thanks to such new technologies as revolutionary microscopes.

At this minuscule scale, our world seems to turn on its head: the laws of physics no longer apply and everyday materials abruptly change their behaviour. Opaque substances, like copper, become transparent; stable elements, such as aluminium, burst into flames; normally safe substances, including latex, become poisonous; and gold turns to liquid at room temperature.

This apparent bending of the natural order brings both benefits and dangers for health and the environment. On the plus side, the technology can be used to produce drugs that target particular organs, or that seek and destroy cancer cells scattered through the body.

Nanotechnically engineered catalysts are being tested in cars to reduce carbon monoxide emissions. The technology

is also helping to develop water filtration systems to produce clean drinking water, and is being used in paints to coat windows and walls to improve insulation and cut energy use, and thus the emission of greenhouse gases.

But there is also a downside. When taken into the body, nanoparticles can overwhelm the immune system. They can also penetrate deep into the lungs and threaten to cause respiratory diseases, accumulate in the liver, cross the blood-brain barrier which protects the body's most vulnerable organ, and promote the formation of the so-called 'free-radicals' which can help cause cancer. In the environment, they can transport pollutants more quickly through the ground and enable them to be taken up more easily by plants, which may be eaten by animals and people.

Yet, funded by a torrent of government and private research money, the technology is expanding at enormous speed. Last year, \$50 billion worth of products worldwide used nanotech: in just three years this is expected to rise to a staggering \$2.6 trillion. 'Nanotechnology is creating fundamental changes in almost everything on Earth,' says Mike Roco of the United States National Science Foundation, 'and what we are seeing now is just a hint of what's to come.'

The danger is that most attention will be paid to the upside of the technology, and not enough to its drawbacks, in the rush to commercialize it. Swiss Re, the world's second biggest reinsurer, is deeply concerned, fearing massive compensation claims if nanotechnology causes widespread health damage. And Prince Charles, the heir to the British throne, is not alone in warning that the public will only accept it 'if a precautionary approach is seen to be applied'.

Evident Technology





Photos: Bayer

Standing together

'LIKE A MONET PAINTING, the environmental situation on Earth is made of millions of tiny strokes. Each one is vital. But to understand the picture as a whole, one has to step back,' astronaut Gerhard Thiele told the 150 delegates of the 2007 Tunza International Youth Conference. The young environmentalists, aged 14 to 25, from more than 100 countries, met in Leverkusen, Germany, to bring their experiences and knowledge to bear on the theme of Technology in Service of the Environment. 'International conferences like this are incredibly powerful,' said Caitlin MacLeod from Canada. 'Right off the bat there's energy to share experiences and skills.'

A spectacular opening ceremony kicked off the biennial Conference – this year hosted by Bayer, UNEP's partner and Tunza sponsor. There were dance performances, films and welcome messages from Nobel Peace Prize laureate Wangari Maathai, rock group Silbermond, World Cup winner Rudi Völler and Chinese pianist Lang Lang. The new Tunza logo and theme song *Time for Action**, created by Bayer for the Conference, were unveiled.

'It is possible to be both commercially successful and environmentally committed,' German Environment Minister Sigmar Gabriel told delegates – a theme backed by UNEP

Executive Director Achim Steiner, who explained how technology should play a role both in economic growth and environmental sustainability. 'And don't allow anyone to tell you we can't afford sustainability,' he warned delegates, urging them to study how Germany 'is rapidly rethinking its own future' on environmental protection, harnessing its advanced technological know-how.

Over the next few days delegates kept pace with a packed schedule: they gathered to share details of their own work in plenary sessions, then broke into regional meetings to discuss local problems. There were stark contrasts: North Americans and Europeans focused on sustainable lifestyles and technology transfer, while delegates from Africa discussed how basic needs, such as clean water, could be met.

Workshops allowed delegates to explore such subjects as biomass and future fuels, and to consider different views. Morteza Farajian, from Iran, told delegates: 'In the future we will need biofuels. We can even feed animals with them, so why not?' But Zhang Boju of China pointed out that while biomass was an exciting alternative, it had limitations: 'China needs energy for development, but there's no chance right now for biofuels because of food insecurity.'

TUNZA YOUTH ADVISORY COUNCIL 2007-2009

The 2007-2009 TYAC (pictured above) was elected by delegates at the Leverkusen Conference. The Council advises UNEP on ways of engaging young people in its work and informs young people about UNEP's programmes.

Front row, left to right

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* The Tunza song can be heard on www.tunza2007.unep.bayer.com

The delegates were given a guided tour of Bayer's chemical park in Dormagen, with a special emphasis on how the company breaks down hazardous wastes. Jamal Alfalasi of the United Arab Emirates reported: 'The solid waste that's left over is used to build roads... everything is recycled. Even the air that goes out is clean!'

Being in Leverkusen made it possible to see how the nearby city of Cologne deals sustainably with its municipal needs. Some delegates visited the city's waste-incineration plant, where energy is recovered and recycled. Others watched drinking water being purified from groundwater and the river Rhine. Other excursions focused on renewable energy facilities, such as a test wind farm, a photovoltaic test lab and a rapeseed mill.

Delegates noted that some of their countries were behind Germany technologically or had different needs, but agreed that these innovations showed what was possible. Handy Acosta Cuellar of Cuba compared Cologne's water production with that of his own country: 'We have lots of water, but bad pipes mean we lose 50 per cent of it before it reaches our houses.' And when Norbert Machipisa of Zimbabwe saw wind turbines for the first time, he marvelled, 'I think this is one of those greatest things I've ever seen. If we had this in Zimbabwe, we wouldn't need electricity from other countries.'

There were times to relax, such as during a dinner-and-dance cruise on the Rhine and a visit to Cologne's 13th-century cathedral. But as the week wound down, delegates were setting themselves tasks. Said Maimuna Sarr of Gambia: 'When I get back I'll advocate litter boxes in the streets, which we don't have. I also plan to build partnerships with my national environmental agency to involve young people in making our environment as clean as possible.' Raising awareness was a priority for Ahmed Abbas Mahmoud of Sudan. 'Most of the young people in my communities are not educated, so I must go back and implement some of the educational ideas I learned here,' he said.

By the last day, everyone agreed the most valuable part of the Conference was forging friendships that would strengthen their work. Ambitions coalesced in a formal declaration of the delegates' commitment, concluding, 'As we consider the state of the planet that we will inherit, we stand together to address the challenges of our generation.'

This was underlined as delegates planted more than 200 trees as a contribution to UNEP's Billion Tree Campaign. Oak, wild cherry, beech and hornbeam were planted so that in time, when seen from above, their different coloured leaves might suggest our planet.



Material values

Whole chapters in the long history of humanity have been defined by the materials they used: the Stone Age, the Iron Age, the Bronze Age. That gives some idea of how important they are for our development. Now people manufacture many of the materials we take for granted; we hardly stop to think who makes the foam in our beds, for example, or the fibres that use light to transmit telephone signals.

Materials science is the study of how materials behave, engineering new ones and finding uses for them. Of course, new materials have endless applications, from furniture to medical equipment or electronics. And they are increasingly being developed to benefit the environment.

In 1989, for example, chemist Pat Gruber of Cargill Dow came up with the idea of biodegradable plastic made of corn. He brewed the first batch in his kitchen. Now he uses the process to make compostable plastics based on corn syrup that require half as much fossil fuel as traditional ones, saving energy and solving an intractable waste problem at a single stroke.

Dr Joachim Petzoldt of Bayer Material-Science gives another example: polyurethane construction foam. 'It's watertight and airtight; and just 50 millimetres of the foam has the insulating properties of 1.7 metres of brick,' he says. This is important. Around half the energy we consume is used in heating and cooling buildings, so it is vital to insulate them properly. In the same way, new materials are needed to improve the use of the sun's energy through solar panels and cells.

To take another example, researchers at Cornell University have found a way to protect ships' hulls without damaging marine life. Since the 1970s, ships have used defouling paints containing tributyltin (TBT) to keep their hulls free of barnacles and algae that cling to them and slow them down, as well as risking the spread of invasive species. But TBT – which has been called the most toxic substance ever released to the sea – has devastated populations of dog whelks by stopping them reproducing. In 2001 the International Maritime Organization agreed a treaty to phase out TBT, but nations have been slow to ratify it. The Cornell scientists have developed a non-toxic material that uses a thin water barrier to protect ships instead.

It's a material world, and technology is needed to find and develop the materials that will keep it healthy.

CAPTURE

A few experimental carbon capture facilities are under way – in Algeria and Norway, for example – separating CO₂ from natural gas, and storing it below ground. Others are being developed all over the world.

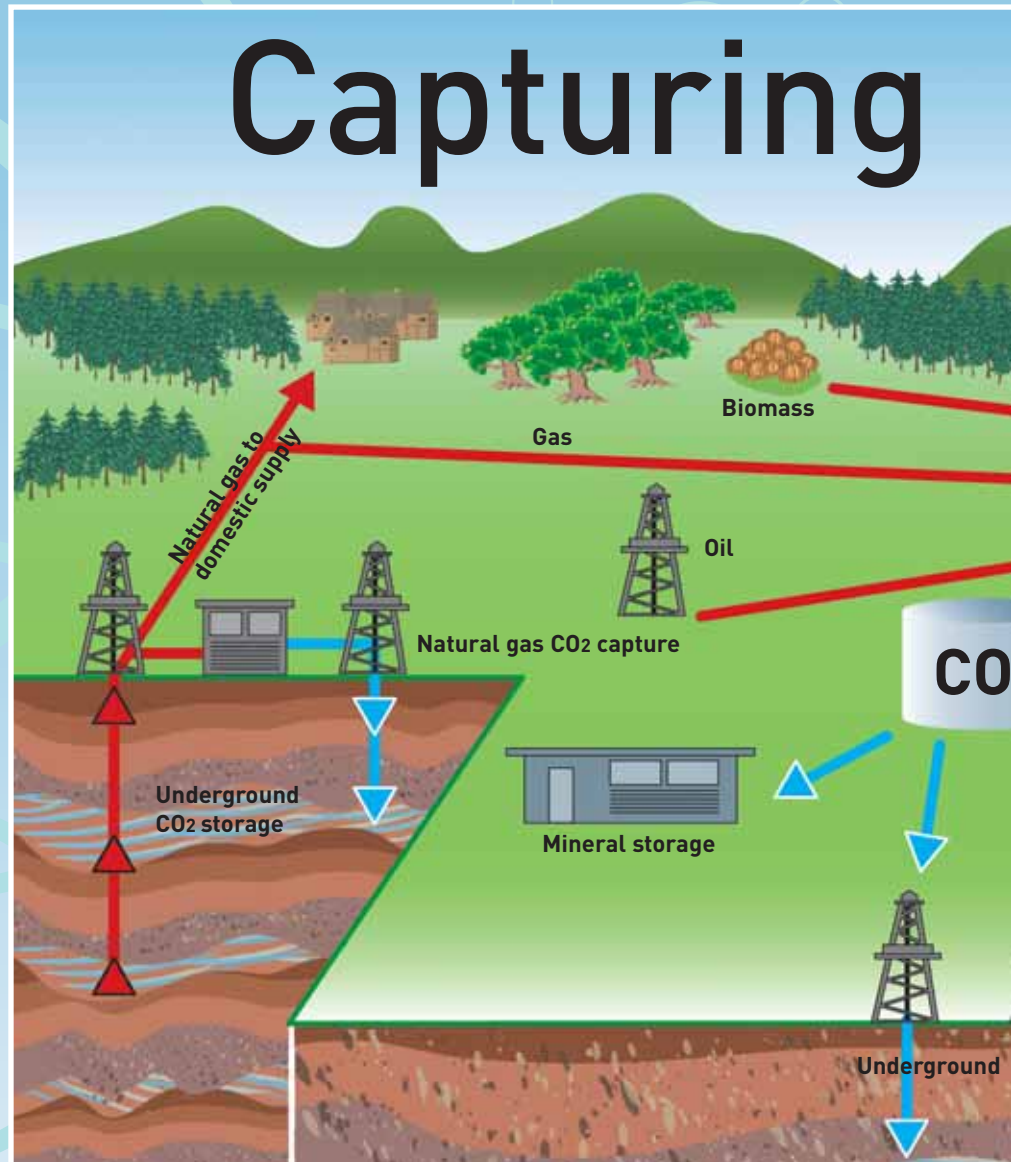
Carbon can be captured at two different stages. The first is pre-combustion. Coal, for example, can be turned into gas: hot air and steam are used to separate out hydrogen, carbon monoxide and then CO₂ for storage.

The second and more developed method is to capture the CO₂ post-combustion (after it has been produced by burning fuels) by separating it from other waste gases and retaining it. This is particularly designed for power stations and other big energy-using industrial plants. It can be made more efficient through new technologies like oxyfuel combustion, where fossil fuels are burnt in pure oxygen, leading to the emission of only CO₂ and water, which can then easily be separated. But this is costly and requires a lot of energy, making it a relatively limited option.

MINERAL STORAGE

Yet another idea is to harness mineral carbonation, a natural process in which CO₂ combines with common metal oxides: over millions of years this produces such stable products as calcium and magnesium carbonates. Scientists are now investigating how increasing temperature and pressures might speed the process up.

The stability and permanence of the reaction make it very unlikely that the CO₂ would be able to re-enter the atmosphere, and the new carbonates can be used as building materials and in medicines, cosmetics and even toothpaste. But this research is only in its infancy.



Unfortunately, we will be burning lots of fossil fuels – oil, gas and coal – for a long time to come. The use of alternatives, particularly renewable ones like the sun, wind and biomass, is expanding, but cannot increase fast enough to take over the burden of powering the world in the near future. And countries that have reserves of fossil fuels will want to exploit them.

This means that vast amounts of carbon dioxide (CO₂) – the main cause of global warming – will continue to be produced for decades as fossil fuels are burned. If it gets into the atmosphere it will accelerate climate change,

Taming the sun

Solar energy starts in a natural nuclear fusion reactor at the heart of the sun, where immense pressure and a temperature of 16 million degrees centigrade fuse nuclei, releasing energy in the process. For the past 50 years, scientists have dreamed of reproducing this on Earth, but so far have been able to generate just 12.9

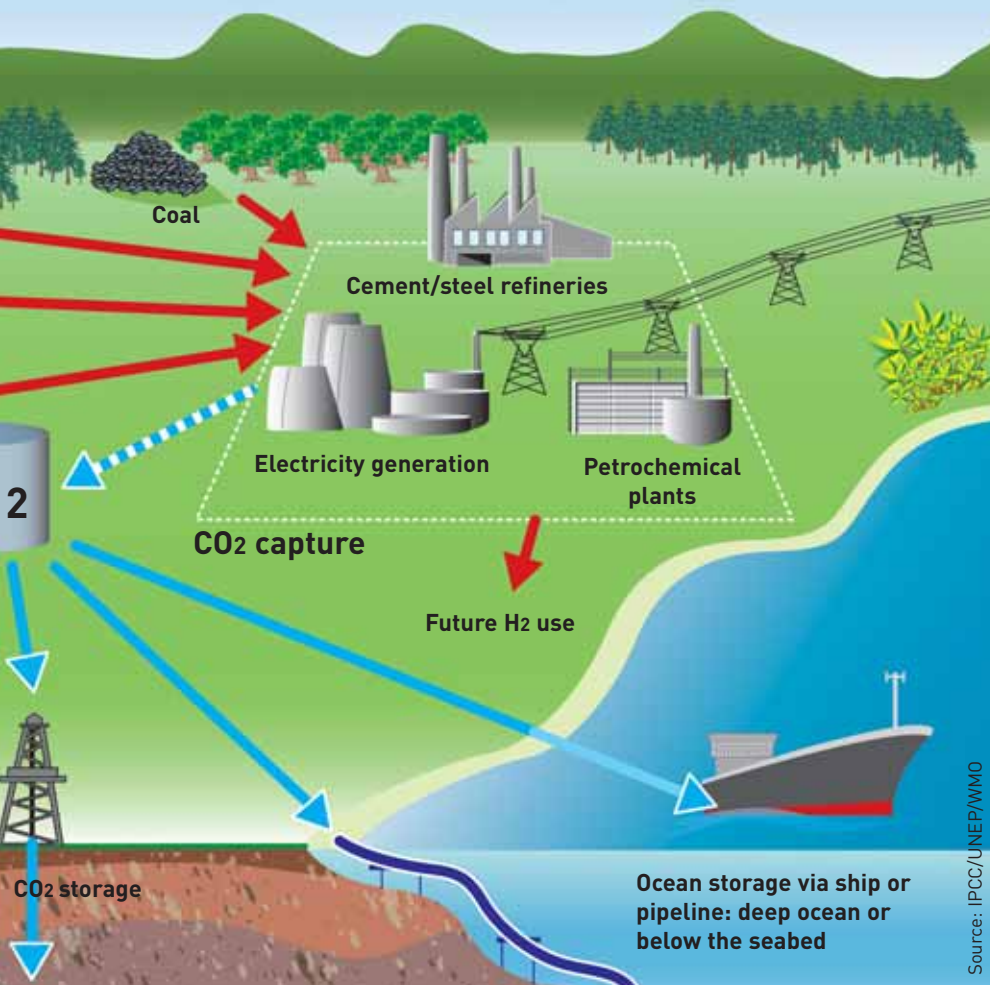
megawatts – and then only for a moment and by using far more energy than is produced.

Trying to harness fusion demands complex and expensive technologies. An international seven-partner coalition of China, the European Union, India, Japan, the Russian Federation, the Republic of Korea and the United States of America – called ITER – is spending an initial \$10 billion on a 35-year attempt.

If it works, fusion could supply energy without contributing to global warming. Just 1 kilo of its fuel – deuterium and tritium – could produce as much energy as currently comes from 10,000 tonnes of fossil fuels, enough to provide power to around 7,500 Europeans for a year. Deuterium, an isotope of hydrogen, is easily acces-



CARBON



UNDERGROUND STORAGE

Once CO₂ is captured it has to be stored so that it cannot get into the atmosphere. The most talked-about way of doing this is to put it back into the 'underground geological reservoirs' created by removing the fossil fuels in the first place, such as abandoned coal mines or old onshore or offshore oil and gas fields.

This can have extra benefits. Pumping CO₂ into wells can make it possible to get more oil out of them. And pumping it into coal seams can release trapped methane gas for use as fuel. The main concern about the practice is that any CO₂ that escaped to the air from the reservoirs would contribute to global warming.

OCEAN STORAGE

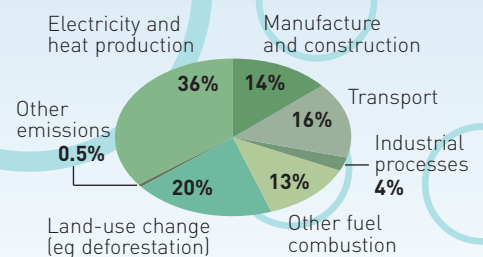
CO₂ could also be stored by pumping it into the ocean from ships or through pipelines, to be absorbed by the waters or ingested by phytoplankton. It could be sent directly to the seabed, more than 3 kilometres down, where the high pressure turns the gas into a liquid much denser than seawater, so it can't rise to the surface.

But there are serious concerns. The world's oceans are already turning acid through absorbing the CO₂ that is polluting the air, and this threatens much of its life. Pumping in more CO₂ could actually make this worse.

and may well cause it to escalate out of control, creating a much less hospitable planet for people and wildlife alike.

Those grappling with this conundrum are increasingly placing their hopes in carbon capture and storage, new technologies designed to catch the gas before it is released into the atmosphere and then store it safely. Although development in this field runs far behind the expansion in the use of fossil fuels, and often competes for funds with expensive alternative energy technologies, it needs to be given a much higher priority if its potential is to be properly realized.

Where manmade CO₂ emissions come from



sible from water, while a tiny amount of tritium – another isotope of hydrogen – kicks off the production of more tritium when lithium, a common metal, is bombarded with neutrons during the fusion reactions. ITER estimates its plant will generate 60 tonnes of waste a year, which will be toxic for around 100 years compared

with thousands of years for waste from nuclear fission reactors.

Construction of an experimental reactor is under way in Cadarache, southern France, and ITER hopes a demonstration power plant will be operational by 2040. In the meantime, the International Fusion Materials Irradiation Facility – also at Cadarache – has started work on developing the new materials necessary to withstand temperatures of up to 100

million degrees, more than six times as hot as the sun.

'Fusion won't be available in the short term,' says Kaname Ikeda, ITER's project leader, 'but the problem of providing viable energy sources in the future is not going to get any easier even if (energy) conservation, CO₂ sequestration and renewables are more widely used. We need to see whether and to what extent fusion can contribute.'

Virgin Earth

Sir Richard Branson – if an international BBC poll is to be believed – is one of the top 10 individuals that people would like to lead the world. Nelson Mandela comes first, of course, but the British entrepreneur is securely in there at number nine, one below Archbishop Desmond Tutu, the Nobel Peace Prize winner, but two ahead of the former UN Secretary-General Kofi Annan.

He is also a recent prominent convert to the battle against global warming. A sceptic until two years ago, the founder of Virgin Music and Virgin Atlantic Airways began reassessing his position after Hurricane Katrina devastated New Orleans. In September 2006 he pledged to invest \$3 billion of his companies' profits over 10 years to fight climate change through Virgin Fuels, a new venture dedicated to developing clean alternatives to fossil fuels.

Five months later, he announced that he would give a \$25-million reward to the person or organization who produces the best commercially viable way of removing manmade carbon dioxide from the atmosphere.

Starting out

Sir Richard – a dyslexic who left school at 15 – started his first successful venture, a magazine for students, a year later. At 21 he opened the chain of record shops that became Virgin Megastores, and the following year Virgin Records put out its first release – Mike Oldfield's smash hit *Tubular Bells*. The label went on to sign megastars like the Rolling Stones, Genesis and Janet Jackson. A bewildering array of enterprises and companies followed, including airlines, books, trains, credit cards – and now even Virgin Galactic, a bid to take 500 people a year into space from 2009.



Robert Leslie

Branson caught the world's imagination in the 1980s and 1990s with record-breaking manned balloon flights, and more recently by helping to found the Elders, a group of respected world figures (including Mandela, Tutu and Annan) who will grapple with intractable world problems.

Meeting the challenge

After Hurricane Katrina, the media giant Ted Turner challenged him to build a refinery for 'clean, rather than dirty fuel' and introduced him to the United Nations Foundation, which Turner had started as part of a \$1-billion donation to the UN, and which has helped lead the way in pushing for biofuels in the United States of America. Branson flew to Washington, met with experts – including the foundation's president, Senator Tim Wirth – and says: 'I decided that what they said was right.' He then invested in seven biofuel refineries.

He insists his initiative is 'a business venture, not a charity', adding: 'The only way global warming will be beaten is if we can create an alternative fuel industry that pays its way.'

Taking it seriously

Virgin Fuels will research wind, wave and possibly even nuclear power, but it is primarily focused on biofuels. Branson accepts that they have drawbacks and aren't '100 per cent friendly', but insists they're better for the environment than conventional fuels, and are a 'crucial near-term transition technology'.

He explains: 'We're starting with corn, but plan to move to 100 per cent climate-friendly cellulosic ethanol, which can be derived from fibrous, fast-growing crops and agricultural waste. We're developing enzymes that can transform these readily available fuel sources – whether prairie grass, corn stalks, willow trees or household rubbish – into fuel.' In turn, he adds, this 'will certainly be followed by other long-term clean-fuel solutions that will eventually take its place'.

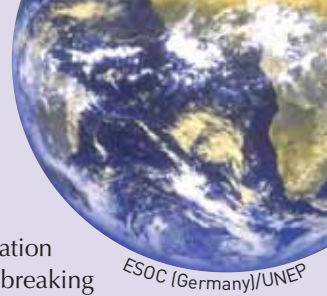
Working for change

Branson hopes to develop a clean fuel capable of flying 747s, but he also urges airlines to 'adopt simple, low-tech ways to save energy. For example, instead of turning engines on at the gate and using 2 tonnes of fuel to get to the end of the runway, we're towing planes with an electric tug.' He goes on: 'I'm encouraging the aviation industry to embrace such ideas. It will save airlines a lot of money while cutting emissions.'

He believes governments 'should be making sure that by 2020, for instance, every single car is a hybrid, flex-fuel car that runs on a combination of electricity, ethanol, and gasoline', adding: 'They should mandate all fuelling stations to have ethanol well before then. We need world leaders to treat this as seriously as World War II.'

'I feel all adults have a duty to pass on a pristine planet to our children. We have to wean ourselves off our dependence on fossil fuels. My generation has the knowledge, the financial resources and, as importantly, the willpower to do so.'

'I'd also love to have Virgin recognized as the most respected brand in the world. If it can be a leader in tackling global warming, and that enhances the brand, that's fine. It will enable us to tackle the problem all the earlier.'



ESOC (Germany)/UNEP

Growing home

Building tree houses is for the birds. The new thing is to grow one. Architect Mitchell Joachim and colleagues of the Massachusetts Institute of Technology's Human Ecology Team have developed the Fab Tree Hab concept, to cultivate dwellings at the roots of trees. The idea is to get them to grow using an ancient method called pleaching – weaving branches to form living archways, lattices or screens, over a computer-designed plywood frame that is removed and recycled once the growing structure is stable. The walls will be filled up with woven vines, pockets of soil and living plants (providing food for humans and wildlife), and plastered with cob (see page 21) inside. The houses take at least five years to grow, but could be brought to maturity on a farm and then replanted when sold. Joachim is still fine-tuning the concept, investigating fast-growing Israeli plants and soy-based windows, but it looks like becoming reality.

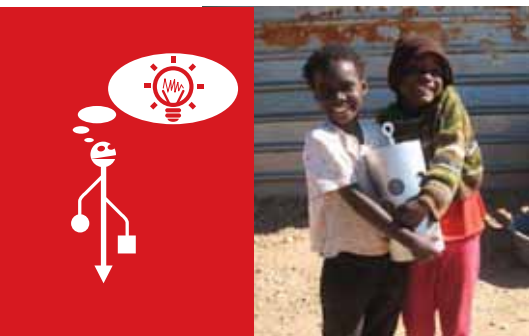


Mitchell Joachim/Terreform

Great

Cool wool

'I wanted to take a product that people use every day and make it so that it didn't use electricity,' says Emily Cummins, the 19-year-old inventor of a solar-powered fridge based on sheep's wool. She came up with the idea while studying for her final school exam and, after visiting South Africa and Namibia before going to university, realized it could be used to keep medicines cool in places with no electricity. The fridge, which looks like a designer pedal-bin, uses sunlight to evaporate water through the wool, which is fitted between two aluminium cylinders; the inside temperature is brought down to 7°C. 'It's a really simple design that people could make themselves using everyday scrap materials,' she says. Recycled aluminium requires less energy to produce than other metals, and the fridge itself is also recyclable. Emily – now at Leeds University Business School – has received awards for her innovation. She is working on making the fridge even cooler, and hopes to get it manufactured soon.



Emily Cummins

ideas

Windy city

Bahrain's World Trade Centre, being built in the city of Manama, is the world's first commercial development designed with integrated large-scale wind turbines. Its two towers rise 240 metres – 50 storeys – from the ground, looking like a giant pair of sails rising from the Persian Gulf. They are joined by three 30-metre bridges, each supporting 29-metre windmill blades. The towers are positioned against the prevailing winds, allowing the turbines to generate 1,100 to 1,300 megawatt-hours (MWh) per year – equivalent to lighting 300 homes – and provide 11 to 15 per cent of the centre's energy needs, eliminating around 55 tonnes of carbon emissions.



Atkins

Dragon drag

They call it the Green Dragon, and it's the world's first roller coaster powered by its passengers. Thrill-seekers at the GreenWood Forest Park – an eco-friendly amusement park in Gwynedd, Wales – first get into a funicular carriage, based on those used in Welsh slate quarries 200 years ago, and ride down a short hill. Their weight both pulls the empty roller coaster up the incline and generates enough electricity to get the ride started. Passengers then get out of the carriage, climb back up the hill and board the roller-coaster which sets off on the 250-metre track, reaching a top speed of 40 kilometres an hour, then leaving it at the bottom to be pulled up by the next load of passengers. So efficient is this system that over a year's operation it is expected to generate more electricity than it consumes.



GreenWood Forest Park

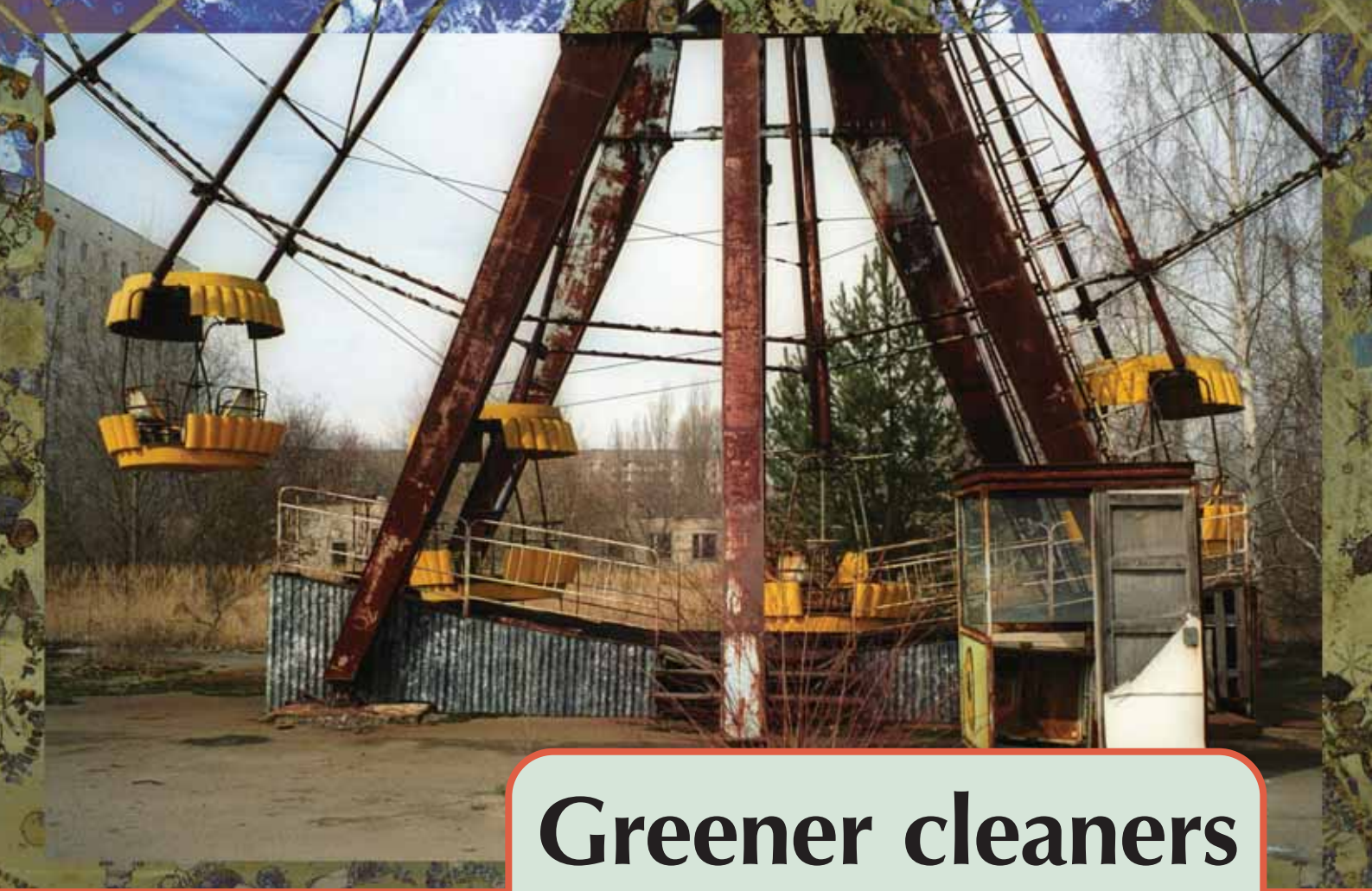
Gary Fixler

City sun-around

Cars with sun roofs are two a penny, but Xebra Xeros are something else. These colourful three-wheeled vehicles – which come as a four-seat 'sedan' or a two-seater 'truck' – have solar panels attached to their roofs. Marketed by an electric car company called ZAP, which stands for Zero Air Pollution, the solar-electric hybrids can travel up to 40 kilometres at up to 65 kilometres per hour – fine for city driving – on only the sun and with no emissions. The batteries recharge whenever the cars are parked in direct sunlight, or can be charged with electricity at a standard wall outlet.



Technology and the environment



Greener cleaners

The Chernobyl nuclear accident (with its deserted ferris wheel, pictured above), civil wars in the Balkans, oil spills, industrial waste dumps, the disposal of chemicals, fertilizers and pesticides, and poorly managed irrigation schemes – all have rendered soils unusable.

In western and southern Europe alone, says the European Environment Agency, there are estimated to be 1.8 million sites of seriously contaminated land. The polluted soils must be removed before anything can be built on them to avoid hazards to health. And the pollution often seeps into the groundwater, endangering water supplies and damaging the environment, sometimes far from the source of contamination.

Now, a new solution is increasingly being developed, harnessing the power of living organisms – plants, fungi and microbes – that feed off toxins and pollutants, and so act as green cleaners. It's not a simple process: different organisms are needed in different environments to extract different impurities in different ways. And some potential organisms require refining before they will work, through breeding or, sometimes, through careful genetic modification.

Take the water hyacinth. A rampant weed that chokes rivers and lakes over much of the world, it is proving a life-saver in Bangladesh. Arsenic, naturally occurring in the soil, has poisoned wells, contaminating the drinking water of more than 55 million people. But the aquatic plant thrives there, sucking the arsenic out of the water and storing it in its stem and leaves.

Similarly, the saltplant (*Atriplex*), as its name implies, absorbs salts from the ground to help it retain water and survive droughts. So it can restore soil made salty and infertile by poor irrigation. It also absorbs up to 30 times as much boron – used in making fibreglass and in the nuclear industry – than is tolerated by most plants.

Fungi can also clear pollutants by breaking them down biologically. Many mushrooms, for example, secrete enzymes that deconstruct long chains of hydrocarbons, turning oil and pesticides into harmless particles. The same process can even eliminate dangerous nerve agents including VX – although governments seem hesitant to explore or disclose this relatively unharnessed potential.

More recently, researchers have been artificially altering microbes to consume specific toxins, breaking them down and rendering them harmless – or in some cases actually beneficial – to the soil. The *Geobacter* proteobacteria has been modified to enhance its ability to consume metals, radioactive materials and oil compounds. It also shows promise as a natural battery for use in nanotechnology, converting human and animal wastes into electricity.

Compare these convenient pollution-busters with having to move and dispose of hundreds of thousands of tonnes of topsoil, or with creating exclusion zones, like the one covering a 30-kilometre radius around Chernobyl. And they do not usually give off harmful by-products. But, as with everything in the environment, care has to be taken in their use. Unforeseen effects can all too readily occur, especially when working at the frontiers of knowledge.

BioFuels

Perennial dilemma

Most food crops – wheat, rice, maize and barley – are annuals: they mature and die within a single year and reproduce by seed. After harvest, the bare earth is easily eroded by wind and water: each year, the planet loses 1 per cent of its topsoil in this way.

Now scientists are urgently trying to develop viable perennial food crops – either longer-living versions of current staples, like wheat and sorghum, or alternatives like the leguminous Illinois bundleflower and wild triga, a relative of wheat that contains almost 66 per cent more protein but no gluten.

Researchers are identifying wild perennials and cross-breeding them amongst themselves or with annuals. They select the ones that produce the biggest and most plentiful seeds, give as reliable yields as annuals and live for several years. 'If we make plants that are tougher, we can use water and nutrients more efficiently,' explains Dr Stephen Jones, who is trying to breed a perennial wheat.

Perennials have many benefits. Fields don't have to be ploughed and planted every year, helping to stabilize soil, prevent erosion and save fuel. Perennials' root systems are more extensive, reaching water deeper in the ground, so they are more likely to survive drought and, in some cases, higher temperatures. They help rebuild the soil and absorb carbon dioxide from the atmosphere all year round. And they naturally capture more nutrients and are better at resisting diseases and pests – qualities lost in their cultivated counterparts – thus requiring fewer chemicals to keep them healthy.

Ken Warren, managing director of the Land Institute in Salina, Kansas, who is working on breeding perennial wheat, sunflowers and sorghum, says: 'You name an abuse from farming – soil erosion, the use of hydrocarbons, pesticides and herbicides – and we can get rid of it with perennial crops.'

It takes a while. Some scientists plan to use genetic modification to speed it up, but most are using traditional cross-breeding methods. Even Dr Jones admits that it would be future generations who would benefit. 'It won't be in my lifetime,' he says.

BACK at the birth of the motor car, it looked as if cars would be powered by biofuels. Henry Ford designed his famous Model T to run on fuel made from corn and hemp, and the first diesel engine burned pure peanut oil. Rapidly increasing supplies of cheap crude oil soon replaced them, but now the world is beginning to turn to them again.

Already nearly half of Brazil's cars run on biofuel. The United States plans to cut its use of petrol by a fifth over the next decade, stepping up biofuel production to compensate, and the European Union has agreed that biofuels should account for a tenth of its countries' motor fuel by 2020. The attraction is that it offers a substitute for oil, whose production is expected to begin to decline in the next decades – and, above all, it could help combat climate change by reducing the burning of fossil fuels, the main source of carbon dioxide.

The two kinds of biofuel – ethanol (made from sugar- or starch-rich crops like corn or sugar cane) and biodiesel (traditionally made from vegetable oils from palm, soy and rapeseed, and from animal fats) – are theoretically carbon-neutral because the carbon released by burning them is reabsorbed by the plants growing for the next crop. In practice, it is far less simple because huge amounts of fossil fuel are often needed to grow, harvest, make and transport the 'green' fuels.

Producing ethanol from corn is particularly fuel-intensive: one authoritative study suggests that the process from seed to tank may burn a third more energy than is produced. Palm oil is a much richer source of energy, but when rainforest is burned down to grow oil palms or soy – as often happens – many times more carbon dioxide is released than saved.

Besides, destroying the forests dries up water sources, denudes the soil, and drives rare species like the orang-utan towards extinction. Meanwhile, the rush to make ethanol from corn – by 2008 one third of the United States crop will be devoted to it – is already driving up food prices, badly affecting the poor. And even using the entire United States harvest would only produce enough fuel to power a sixth of its cars.

Biofuels can, of course, be produced less damagingly: UNEP wants international standards to ensure that their benefits outweigh their disadvantages. But hopes are increasingly focusing on the next generation of the technology.

Jatropha nuts, from a tree that will grow on marginal land, offer some promise. But the greatest efforts are going into finding a way of cheaply turning cellulose from the woody parts of plants into an even richer biofuel. The breakthrough, expected in five to 10 years, would enable fuel to be made from harvest wastes like corn stalks – eliminating competition with food supplies – and from trees and grasses, such as willow or switchgrass, which could be planted on wasteland and used to stabilize soils.



da5idblacksum/David Metz/Flickr



Designing the future



WTI Bangladesh; Nir Avneyon/Flickr

New cars and cutting-edge technologies are both sometimes described as ‘boys’ toys’ – but you won’t find Heidi Hauenstein and Stephanie Johns using the phrase. As engineers, they are both at the forefront of research to produce greener cars.

Hauenstein, a member of the Rocky Mountain Institute’s Breakthrough Design Team, is working to radically reduce the weight of vehicles while maintaining their overall safety. She’s also looking for ways to make energy-efficient cars look better, so that they can shed the eco-geek image and hold their own with such legends as Enzo Ferrari and Pininfarina. Johns, another member of the team, is developing advanced energy-storage systems for cars and electrical hybrid vehicles that can be recharged by plugging them into the mains – and examining the efficiency of heavy vehicles like trucks and earth-movers.

Designing our future

‘Women need to be part of designing the future, or it won’t suit us,’ says Jackie Edwards, winner of the 2006 Aurora Blackberry Women in Technology Award. That’s always been the case: women invented the medical syringe (1899), the electric water heater (1917), the car’s muffler (1917) and its windshield wipers, and Kevlar (1966), a fibre used on everything from tyres to space-suits and bullet-proof vests. The remaining prejudice against them is being eroded, not least because the demand for good engineers now outstrips the supply.

Environmental engineering graduate Katy Roelich, who was involved in cleaning up nuclear waste on Christmas Island, believes that engineering requires a fine balance of women’s abilities, ‘not only technical ones, but creativity together with people and management skills’. She now works with

Arup, the innovative designers of Dongtan, the new eco-city under construction in China.

Tough, but possible

Still, succeeding in a male-dominated field takes some determination: Karen Petrie excelled in computer science but was encouraged to become a doctor. Undeterred, she got her PhD specializing in artificial intelligence, and went on to help NASA develop its Topological Observation Prediction System, which ‘watches for things like the greenness of the Earth’s mass and changes in the weather,’ she says. ‘If, for example, the ground in a particular region is a bit brown and dry and the weather is going to be very warm, that could be an indication of an area where wildfires could break out.’

Making the difference

Opportunities for young women are also opening up in Asia, where traditional limitations on women’s roles can add to the barriers to success. The Asian University for Women – committed to identifying and nurturing the careers of women in science throughout Southeast Asia – will open in Bangladesh in 2008 with environmental engineering and sustainable development as one of the pillars of its graduate programme.

Even students can make an immediate and substantial difference in improving both people’s lives and the environment. Environmental engineering student Alia Whitney-Johnson is working to maximize the efficiency of a turbine design on a micro-hydropower system in Guatemala. ‘Getting to see the practical benefits of the work is exciting,’ she says. ‘My long-term aim is to specialize in sustainable development and to make the right technologies available where they are needed most.’

Green...

The Knitting Philistine



Fashion often seems to repeat itself: yesterday's styles come round again tomorrow, or the day after. But now designers and manufacturers, as they question fashion's ethical and environmental costs, are increasingly recycling the clothes as well. It's not a new idea. Two thousand years ago, used clothing was being shredded and blended with virgin fibres to make yarn in China. And in Europe, waste wool has been respun into a durable fabric – unkindly called 'shoddy' – since the early 19th century.

Recycled materials

Nowadays, attractive fibres can even be extracted from such unusual sources as plastic bottles, which are cut into flakes, melted and woven to create warm, waterproof polyester. The outdoors clothing company Patagonia has been making fleeces from them since 1993, and reckons it has saved around 92 million bottles from landfill and incinerators. And when the fleeces themselves have outworn their welcome, Patagonia offers a recycling programme to transform them into new clothes.

This summer, international retailer Marks & Spencer unveiled school uniforms derived from plastic. Eco-friendly shoemaker Terra Plana produces a range called Worn Again, taking 99 per cent of its material from recycled sources, including car seats, tyres, prison blankets and fireman's trousers. It also produces a leather, indistinguishable from the real thing, from blending used leather and textile fabrics. And for those who can't give up their beloved jeans, you can have them re-crafted into a pair of Kalahari sandals at recycleyourjeans.com.

SO THIS YEAR

New technologies

New green technologies are producing cutting-edge materials, too. One, Lyocell – produced from wood pulp – is soft, absorbent, strong and wrinkle-proof. In Japan a denim-like material is made from banana stems, and vibrant summer shirts are woven from fibre made from stems of ginger, normally discarded as industrial waste after the plant's aromatic and antibacterial leaves have been used in cosmetics and other products. Such materials all use previously untapped resources, and all are biodegradable.

Greener options

Traditional materials, too, are being greened. Conventional cotton cultivation uses loads of water: making one pair of jeans can use up to 15,000 litres, depending on climate and irrigation methods. But new drip-irrigation systems supply the plants with carefully controlled amounts of water so that evaporation is reduced, and researchers are trying to develop high-yielding cotton plants which thrive on much less water. Another solution would be to follow the example of Levi Strauss who, in 1873, reportedly made the first pair of now-iconic jeans from hemp, a cotton alternative with half its ecological footprint. Needing less water and fewer chemicals to grow, the crop nourishes soil and produces a comfortable, durable and chic fabric.

A recent study by the University of Cambridge recommends detailed 'eco-tagging' of clothes to help customers make more informed choices – and feel as good as they look. Then it will be possible to buy clothes of any colour, knowing that they are also green.

Steve Rhodes





Earth works

Homes and other buildings tread heavily on the planet. Forty per cent of all mineral and metal products are used in construction, while making concrete, the world's commonest building material, uses enormous amounts of energy. And once up, buildings made out of modern materials consume a great deal of energy in heating and cooling.

And the number of buildings is constantly increasing as the world's population grows and as family break-up and rising affluence in many societies increase demand. Meanwhile, half a billion poor people, with little access to modern construction materials, struggle to find a decent shelter.

All this is causing a surge of interest in natural building materials and techniques. Low-tech, tried-and-tested, non-toxic, sustainable and affordable, these use local materials wherever possible, and apply techniques that are easily learned and implemented.

Buildings constructed with natural materials can use much less energy. A recent study by British Gas found that 16th century wattle-and-daub houses were far more energy-efficient than present-day ones. Modern knowledge can be used to improve these techniques further – for example by ensuring seismic stability or integrating renewable energy technologies. With input from the best of both worlds, turning towards natural building could help create sustainable homes for modern times. Natural materials include:

RAMMED EARTH

This simple technique consists of building walls by compacting soil and other natural materials, such as gravel, clay or straw, in layers in temporary wooden frames called forms. The layers are tamped down using a heavy rammer – this can be as simple as a 5-kilo hand rammer or as high tech as a gasoline-powered rammer – forming thick blocks. Rows are built on top of each other, making a rock-hard mass so durable that rammed-earth structures more than 1,000 years old still stand in Central Asia, North Africa and southern Europe. Parts of the Great Wall of China were built this way 2,000 years ago. Today, there's a growing demand for commercially built rammed-earth houses, especially in Australia and the United States of America. The method is naturally environmentally friendly: soil is free and locally available everywhere, and little wood is required. The thick walls require no paint or plaster, are soundproof and keep interior temperatures stable, resist fire and termites and are non-toxic. And they're beautiful: they look as though they have grown straight out of the earth!

ADOBE

Sun-dried bricks made of a mixture of clay, sand and mud, sometimes with straw or other materials added, are one of the world's oldest building materials. They may first have been used in the Middle East – where centuries-old

adobe structures still stand – though they are most often associated with Native American pueblos in the south-western United States. Mud bricks have also long been used in South America, North Africa and Spain. Adobe works best in hot, dry climates as it doesn't hold up well to intense rain – and it is great at keeping interiors cool in the desert sun.

STRAW BALE

Straw houses might seem the stuff of fairy tales, but they originated in real life in the plains of the United States in the late 1800s. Bales are stacked to make walls, pinned together with bamboo or reinforcing rods and strengthened with chicken wire. Holes are cut for windows and doors, and the surfaces are plastered. The bales insulate as well as fibreglass, but because the walls are much thicker, they are even more efficient, and tests have proved that when plastered they are also fire resistant. It takes the straw from just 3 or 4 hectares of wheat or oats – or 1 hectare of hemp – to build a small house.

WATTLE AND DAUB

This consists of a timber frame fitted with a latticework of branches, twigs or other flexible wood, called 'wattle'. These are then smeared – or 'daubed' – with a mixture of straw and earth or cow dung, and washed with lime to create a durable, well-insulated shelter. Most often associated with medieval England, France and Germany, this technique has



Eric Feinblatt

Kent Sandvik

counterparts in other parts of the world: in Latin America it is called *quincha*, and in Japan it is known as *komai-kabe*, and uses a bamboo lattice. It is especially good in humid climates because the walls 'breathe', preventing the build-up of moisture inside.

COB

No one is sure where this originated, but it has been used for many centuries in England, where cob structures 500 years old still stand. Similar to adobe, is a mixture of sand, straw, water and soil high in clay. The mixture is made into small loaves called cobs – instead of bricks – and these are then mashed together and sculpted into walls to produce a curvy, fire-proof structure with excellent insulation.

BAMBOO

Over 1 billion people in Asia, Central America and South America live in houses made of bamboo. Light, fast-growing, earthquake-resistant and stronger than wood, this member of the grass family is extremely versatile. Pillars of bamboo can be used as building support; strips of bamboo can be woven together and plastered to create walls; and – when steamed and soaked in a copper solution to protect it against rot – it can be used to replace steel rods. Though bamboo construction isn't as common in Africa, the plant is abundant in East African countries like Ethiopia, where architects and engineers are being trained to use it.

PRESSING ISSUE

They're everywhere. Plastic bags, that is. Every year a trillion more of them are produced. They litter towns and countryside, choke wildlife, contaminate the oceans and fill up waste dumps.

Dr Caroline Baillie, however, sees them as a way of tackling poverty. A professor of materials engineering at Queen's University in Canada, she is the brains behind Waste for Life, a network of people seeking solutions that help the environment and empower local people. She wants to use the bags to create composite materials.

'These are materials where the sum is greater than their parts,' Baillie explains from her temporary base in Buenos Aires, Argentina. 'Fibreglass is a composite, as is the carbon fibre used to make motorbikes and aircraft. But we're focusing on reinforced plastics.' Strengthening plastic with such fibres as jute, flax and agave is not a new idea, but Waste for Life's innovative approach aims to bring together engineering, the environment and social justice.

Rubbish pickers, or *cartoneros*, in Buenos Aires sort through garbage to salvage cardboard, plastic and paper and sell them to recycling middlemen. 'The *cartoneros* pick their way through the rubbish left on the pavements late at night,' Baillie explains. 'They're self-employed, self-organized and doing the city's dirty work: they don't own the waste, but they are amongst the few who are currently preventing it all from going to landfill.'

But what about the plastic bags?

'Although there are loads of them,' Baillie explains, 'plastic bags have no resale value, and go straight to the landfill where they photo-degrade – breaking down into tiny toxic pieces that contaminate soil and water.' Back at the Waste for Life lab in Canada, engineers are developing a chemical-free hot press that will convert waste plastic bags and salvaged cardboard into ceiling tiles. Using about as much electricity as a household iron, the press will be easy to use and cheap to replicate.

When the prototype press is ready, it will be shipped to Buenos Aires, where it will enable the *cartonero* collectives to enter the ceiling-tile business. Plans are under way for a similar system in Lesotho, Africa, using fibre from agave, a cactus-like plant, instead of cardboard.

'We're trying really hard to tread carefully,' says Baillie, 'and to decide how best to sort ourselves to organize a long-term project. We're learning every day and because we are here without funding requirements we are so much more flexible; able to listen to the people on the ground and modify the project based on their recommendations.'

She has also set up a blog (<http://wasteforlife.org>) 'to help other people around the world learn from our process... and our mistakes'.

Straight to the roots

It's one thing to get hold of water for growing food in hot, arid places, but quite another to keep it once you've got it. All too easily it evaporates away before it can do much good. Since Roman times, at least, farmers have tackled this by using clay pots, with wide bellies and narrow necks, to water plants underground at the roots. Buried up to their necks, the pots are periodically filled with water which then seeps through the clay, keeping the surrounding soil consistently moist. Archaeologists suspect several civilizations developed the pots independently, as they have been found in Zimbabwe, China, Iran, Pakistan and Spain. Spanish settlers, who call them *ollas*, introduced them to North and South Americans who still use them. Small-scale agriculture in Central and South America uses a modern adaptation, where the pots are completely buried and refilled through pipes.



J Victor Espinoza/NMSU

Super grass

Medicine, pesticide, cosmetic ingredient, pollution treatment plant and soil conserver, vetiver grass seems to have it all. The tall, tufted perennial – widespread in India and Thailand – has long been used to treat stress and depression, and to stimulate the circulatory system and the production of red blood cells. Sachets of its powdered roots are used to protect cloth from moths and insects, and its roots are also grown commercially to produce a fragrant oil for aromatherapy and cosmetics. In 1987, World Bank scientists discovered what Asian farmers had long known: the roots of the drought-resistant plant bind soil to a depth of 3 metres, hold moisture in the soil and help to recharge aquifers. More recently they have also been found to filter pollutants, from sewage to heavy metals. And because it grows in water as well as soil, vetiver can be used to clean up ponds and reservoirs.



Stefan Ottomanski

Dark soil

For four millennia, indigenous people in Brazilian Amazonia have enriched its soils with rich, dark earth – called *terra preta de Indio* – made by mixing fish bones with charcoal. Scientists are now tapping ancient knowledge of charcoal's ability to help soil retain water and nutrients, and to combat climate change while improving the land. In New Zealand, they are experimenting with using a charcoal product from forestry waste as a substitute for energy-intensive petrochemical fertilizers. Producing charcoal by burning releases only part of the carbon dioxide absorbed by vegetation during its life. Others propose to extract hydrogen and methane from plant biomass by pyrolysis (heating in an oxygen-starved environment), burying the char by-product as fertilizer. Still others are investigating the possibility of using charcoal to absorb greenhouse gases, and then burying it. And, of course, growing the plants that will be used to make the charcoal absorbs carbon dioxide in the first place.



William Nicholson

Earth power

People have used hot springs – water heated by the magma of the Earth's crust – for cooking, washing and heating for more than 10,000 years. Now they are increasingly being used as a renewable source of energy – not that they have ever gone out of fashion. Japan has a long history of hot spring bathing, called *onsen*, and in 1830, Arkansas entrepreneur Asa Thompson began charging a dollar to use similar baths, starting a trend for bathhouse resorts in North America. In 1892, the world's first geothermal district heating system opened in Boise, Idaho: it still warms 200 houses and 40 business premises. In Italy in 1904, Prince Piero Ginori Conti was the first to generate geothermal electricity, using steam to drive a dynamo and generate enough power to light five bulbs. Today, Iceland gets 90 per cent of its domestic heating from geothermal sources, while 24 countries worldwide use geothermal heat to produce commercial electricity.



M Lupidi/UNEP/Topham

On stream

Over 2,000 years since they were first developed, *norias* – water-powered irrigation wheels – are still in use today. Turned by the flow of a river or stream, they dip an endless succession of containers into the water, lifting it up at a rate of up to 50 litres a second and feeding it into troughs or aqueducts that carry it to the fields. There is literary evidence that they were used in Egypt in the 4th century BC, and some experts date them to around 300 years earlier. Described by the Roman writer Vitruvius in 1 BC – and by John Steinbeck in 1940 – they were used widely in the Islamic world and introduced to the new world. Sixteen survived into this millennium on the River Orontes at Hama, Syria – one, 21 metres in diameter, dating from 1361 AD. A new one featuring 100-litre plastic buckets has recently been built in the Mexican state of Veracruz.



Andrew Churches

Farming worms

Worms – farmers' oldest allies – are now being pressed into service for waste disposal. Aristotle called them 'the intestines of the Earth'. As they tunnel through soil, they make space for air and water to circulate, keeping it from becoming compacted and dry, helping crops grow and protecting land from flood and drought. They eat as they go, passing earth and decaying organic matter through their bodies and excreting castings rich in calcium, magnesium, nitrogen and phosphorus, all important nutrients for the soil. Organic gardeners have long used their ability to transform waste into fertilizer through vermiculture – using them to help make compost from recycled garden and kitchen waste. But now, large-scale worm farms are turning livestock manure, municipal organic waste and sewage sludge into fertilizer instead of letting it pollute water, take up space in landfills and emit methane, a greenhouse gas.



Stig Brautaset

Dragon detector

Way back in 132 AD, Zhang Heng, a Chinese astronomer and mathematician, invented the world's first earthquake-detecting machine – a 1.8-metre urn encircled with eight dragons facing in eight different directions. When there was an earthquake, it would cause the mouth of the dragon facing away from it to open, releasing a metal ball to drop noisily into a frog's mouth below it. The device is said to have detected a tremor 644 kilometres away, even though it could not be felt by humans near the machine. In nearly 2,000 years, we have still not moved on from detecting to predicting quakes, even though the technology has changed. The modern seismograph, which uses a pen attached to a pendulum to trace the shock on paper, provides much more information – including the earthquake's intensity and epicentre – and now linked computers capture seismic information at various sites and analyse it in minutes, giving emergency workers a head start.



Caren M Calamita



Scott Camazine/Science Photo Library

TECHNOLOGY

gifts of nature, harnessed by humans

