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Workshop Leader – George McRobie

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Technology for Sustainable Development by George McRobie

Introduction

The choice of technology is one of the most critical choices that confronts any country, big or small, rich or poor. It is a choice with a pervasive influence. It determines what is produced, and how and where it is produced; where people live, who works and the quality of working life; what resources are used, and what support systems, such as finance, education, transport, are required; and depending upon its environmental impact, it determines whether the economic system it has shaped is sustainable or not.

Because conventional ways of measuring economic growth ignore ifs environmental impact, there is today a wide gulf between the economic and the environmental interpretations of what is happening in the world. The business community feels that the world is in reasonably good shape; and it is axiomatic that the more economic growth, as measured by gross national product (GNP), the better. In contrast, on the environmental front every major indicator shows deterioration, forests are shrinking, desert expanding, croplands vanishing, plants and animal species diminishing, air and water pollution accelerating.

It is of course possible to devise ways of measuring economic growth that take into account its environmental impact. One such measure, an index of sustainable economic welfare, was recently published in Britain. This shows a marked difference between the conventional index, GNP, and the new index, ISEW. For the past fifteen years, while GNP per head rose by an average of 2.4% per year, the ISEW fell by no less than 5% a year. This reflects a rising toll of social and environmental costs, and a falling quality of life. A large part of the decline in the ISEW is attributable to the growing impact of resource depletion and long-term environmental damage. Roughly similar conclusions have been reached by researchers in the USA and Germany.

Resource depletion and environmental damage are directly linked with the predominant technologies of the industrialised countries. There is also the human cost of technologies which substitute capital and energy for human skill. The spectre of jobless economic growth is now haunting Europe and North America. Few would deny that the most urgent task of both rich and poor countries today is to discover and introduce technologies that are sustainable: technologies that respect the human need for useful and satisfying work, that minimise damage to the environment, and that conserve the world's resource base.

New Direction

It was in relation to the needs and resources of the developing world that the deficiencies of rich country technologies first became evident. The critical role of technology in economic development was first brought into focus by E.F. Schumacher in the early 1960s. He argued that Third World countries were relying on rich-country technologies at their peril: that the large-scale, capital- and energy-intensive industries of the rich countries would do more to exacerbate than to solve the problems of the poor countries. Such technologies were singularly inappropriate because they:

- Offer relatively few, very expensive workplaces whereas the poor countries, with their masses of un- and underemployed, desperately need very large numbers of relatively inexpensive workplaces;
- Are located chiefly in cities, which offer the mass markets, scarce skills and infrastructure facilities not found in rural areas where the majority of the poor live;
- In many instances, compete out of existence traditional non-farm activities formerly carried on in rural areas;
- Accelerate the migration of people from rural areas to metropolitan centres;
- Make the developing country increasingly dependent upon rich countries for loans, spare parts, skills and markets;
- Distort the cultures, as well as the economies, of poor countries by concentrating economic activity in cities and social elites, breaking down rural structures -technology is not culturally neutral.

Intermediate Technology

In 1965 a group of us helped Schumacher to start the *'Intermediate Technology Development Group'* in London. Our starting point was that mass unemployment and rural misery could be overcome only by creating new workplaces in the rural areas themselves; that these workplaces must be low-cost so that they can be created in very large numbers without calling for impossible levels of savings or imports; that production methods and associated services must be kept relatively simple, and that production should be largely from local materials for local use.

We used the term 'intermediate' to indicate that, in terms of cost per workplace, the technology appropriate to a poor country would lie somewhere between the almost nil cost of a primitive hand tool, and the (say) £20 000 cost of a combine harvester. Thus if a developing country insisted on technologies which needed £20 000 for each new workplace, obviously (being short of capital) they would be able to create relatively few new jobs. But with a technology costing, say, £500, they could create 40 times as many new jobs. The best engineering talent available, we argued, should be engaged on the task of creating or discovering low-cost technologies: tools and equipment that could be owned and controlled by the rural arid urban poor, and with which they could work themselves out of their poverty.

Our purpose was to demonstrate that, technologies appropriate to the needs arid resources of the rural poor could be developed and introduced, and then, by helping to create an international network of like-minded organisations, to change the whole emphasis of aid and development towards small-scale technology really capable of bringing industry into tire rural areas.

At first, and for several years, the Group did not get a very warm welcome either in rich or in poor countries. But then the conventional strategy of development, based on large-scale capital-intensive industries, came to be increasingly challenged by development economists and planners. Many of the large industries proved to be very inefficient, kept going only by protection and subsidies. They did not generate the hoped-for surpluses and they did nothing to raise the living standards of the majority, the rural and urban poor.

By tire mid-1970s the accumulating evidence of the failure of the large-scale industry strategy was accompanied by tire dawning recognition that small-scale, localised industry and agriculture can reduce transport costs, decelerate city growth, produce goods and services very efficiently, and are the best way of distributing incomes. Then came the failure of the African agriculture; the vast and unrepayable Third World debt; and the relentless growth of unemployment in developing countries. These, largely man-made, disastrous developments, served to underscore the that encouraging the poor to behave as if they were already very rich only compounds their problems.

The direct transplanting of rich-country technologies into the South has already done much damage to tire interests of the poor. Mushrooming cities (whose growth is closely associated with cheap oil) continue to grow apace, On UN projections, Mexico City, Sao Paolo, Calcutta, Cairo arid Jakarta will all have more than 15 million inhabitants by early this century, and some of these will have between 20 and 30 millions. While in 1950 there were only six cities with more than 5 million, within the next decade there are likely to be no fewer than 60 The prospects in terms of energy arid food supplies alone are daunting.

Employment prospects are no better. "During the next 10 years another 1.2 billion will enter working age...about a quarter of them will find some form of work in agriculture, industry or services. The remaining 900 million people will be unable to find a regular source of income…" Already more than 1 billion people, according to the *'International Fund for Agricultural Development'*, are below the poverty line in the rural areas of developing countries, and this could become 1.3 billion within a few years from now: misery on an unprecedented scale.

But it could be argued that the developing countries demand Northern lifestyles, and therefore Northern technologies and the kind of economic growth they bring. So is not the task that of adapting Northern technologies, so that they can be absorbed more gradually, equitably arid efficiently? On this view, small-scale, low-cost appropriate technologies are not really an alternative but simply a stepping stone to the conventional technologies and lifestyles of the North.

The Economics of Impermanence

I am certainly not alone in believing this to be a dangerous misconception. In their predominant form, Northern technologies and their associated institutions are not sustainable. This is true of both industry and agriculture.

There is, first, the virtually total dependence of the North upon oil, which has decisively ceased to offer a low-cost, reliable or long-term energy supply; cheap oil has in fact proved to be an environmental disaster. Secondly, conventional industrialisation is on a collision course with the environment. We now see the pollution of groundwater, air and food by industrial and agricultural chemicals; and the appalling prospect of living, if that is the right word, with what are to all intents and purposes permanently lethal radioactive wastes; the destruction of forests and the erosion of arable land; ruthless over fishing, and the prospect of permanent climatic change.

There are, above all, the human consequences of large-scale and highly centralised technology. The alienation and de-skilling of working people by mass production, the substitution of capital and energy for human skill - these have long been recognised but ignored in the interests of economic growth. But unemployment is now haunting both Europe and North America, and unemployment and alienation will continue so long as we treat labour merely as a cost. The growing centralisation of economic power also poses a threat to democratic processes.

We can no longer assume, in short, that conventional technology is appropriate for the purposes of environmental protection, the responsible stewardship of scarce resources, or the human need for useful and satisfying work. We must increasingly find ways of asking and demanding answers to these questions about technological development:

- What does it do to the resource base, renewable arid non-renewab1e?
- What does it do to the environment?
- What are its social and political implications?

Clearly an appropriate technology would be good for people, the environment, and the world's resource base. An appropriate technology is one that would support sustainable development. Today one can speak of an appropriate technology movement because there are many organisations besides *'ITDG'* working in this field. The Group has country offices in Bangladesh, Kenya, Nepal, Peru, Sri Lanka, Sudan arid Zimbabwe.

Other organisations are doing similar work in both rich and poor countries. There is '*Enterprise Works'* in the USA which provides technology and business development services to small enterprises, and has done so in 60 developing countries. Other AT bodies include another in the USA, '*Technoserve'*, *'GRET'* in France, '*GTZ'* (Gate) in Germany, '*SCAT*' in Switzerland and *'IDRC'* in Canada. *'Development Alternatives'* is one of at least six in India and there are smaller groups in several other developing countries.

As yet no government has declared itself to be pursuing a policy of sustainable development; but thanks to excellent organisations such as *'Friends of the Earth'* and *'Greenpeace'*, policies that would ensure a more sustainable industry and society are widely discussed, though not, at least not publicly, by governments. These policies include:

- A determined programme of energy conservation; the elimination of nuclear power; the development of renewable energy sources;
- The progressive introduction of product standards amid specifications leading to long-life products which can be readily repaired, renewed amid recycled;
- A transport policy that rapidly diminishes the damage done by the internal combustion engine; and the promotion of public transport, especially nail;
- A rapid transition towards organic (non-chemical) agriculture;
- The localisation of economic activity, arid the promotion of democratic forms of ownership and control, e.g. by workers, communities.

The technologies that would emerge from such policies, and the values that inform them, would be very different from those which dominate the North - and which hold out no future for anyone anywhere. They do riot, in fact, have a long-term future. Urgent and drastic changes are needed in the ways we treat our planet's resources, both renewable resources arid non-renewable. I will try to illustrate this by considering two of mankind's basic needs, energy arid agriculture.

Energy: oil

For all practical purposes, the decline in oil production and a permanent upward trend in its price is almost upon us. By the year 2050, world oil production could be down to 5 billion barrels a year, about a fifth of current production levels. By the middle of the present century, the primary energy supplied by renewables could be 50% of the total. Most of that will be produced as electricity. Much of the non-fossil sources of power wilt have to come from new technologies such as:

- On shore/off shot-e wind power generators
- Photovoltaic panel arrays
- Biofuels - solid/liquid/gaseous (energy crops etc)
- Residual waste incinerators, methane recovery
- Mini-Hydro units
- Wave arid Tidal Current power generators

Of these, the marine current turbine is a new and very promising development. An "underwater windmill" first tested in the Nile at Juba in S. Sudan in the 1970s was the ancestor of the present turbine. A 15kW marine current turbine was tested successfully in Loch Linnhe in Scotland in 1994. Quite low velocities can produce usable power, for instance a tidal current of about 4 miles an hour can produce the same power as a 40 mile per hour wind, with a much smaller rotor.

A recent study identified 106 European locations with strong marine current resources (many in British waters) and these sites alone could supply 12,500 MW of installed capacity to Europe's grid network (equivalent to 25 big power stations).

Sources of renewable energy are widely spread and this will tend to localise manufacturing and also to reduce transport costs. High cost energy will maximise efficiency of use. Energy consumption in industrialised countries could be reduced 4-fold, according to the energy specialist Amory Lovins.

Danish studies indicate that electricity consumption could be halved by using more efficient appliances; and power station efficiency could be doubled by using combined heat and power systems. Industrial energy consumption could be reduced 4-fold by substituting labour and skill-intensive repair, reconditioning, reuse and recycling for manufacture. This would also cut down transport costs.

Failure to maximise the reduction in energy consumption in industrialised countries before the price of fossil fuel escalates as world oil production passes its peak and irreversible scarcity sets in, would create a major economic crisis.

Developing countries which lack an energy policy informed by the inevitable, rapidly approaching, oil shortage, should consider their policies towards energy production and consumption, and in particular the implications for transport, industry, agriculture and housing. Contemporary third world indebtedness, it is worth recalling, started with the short-lived energy crisis of the 1970s.

In a book published in 1991, the energy and industrial consultant, John Davis listed guidelines for sustainable development, for managers of industrial and business enterprises. Do more with less by:

- Maximising maintenance, repair arid reconditioning;
- Reusing things and recycling materials;
- Designing goods for high durability and ease of repair, upgrading and recycling;
- Use processes which minimise pollution and the waste of non-renewable materials;
- Use energy in ways that minimise waste;
- Maximise the sustainable use of renewable energy and materials;
- Design and operate manufacturing units on a small scale;
- Use technologies which enhance human skills, are user friendly and which match the capabilities of local populations.

A globally sustainable society, in which we can have a satisfying quality of life without irreversible damage to the environment, will require radically different modes, of production and consumption. Human and environmental needs will be met by renewables produced sustainably - agriculture and forestry are obvious examples - and minimum use of non-renewables. It will be a waste-minimising society that attaches high value to durability of goods and maximises "life-extension" measures such as repair, reuse, renewal and recycling It would be a reversal of the present approach which maximises waste and pollution and neglects repairable products. Changes of values, outlooks and behaviour will be as necessary as changes of technology. (This may be why governments shy away from accepting that the end of the cheap-oil era is just round the corner.)

As I mentioned early in this talk, studies in the UK, Germany and the USA have already shown that the present wasteful and heedless way of life is now reducing our real standard of living. While consumption continues to rise, its effects are now counterproductive. The indices that these countries have produced measure sustainable economic welfare. This measures costs as well as benefits of our steadily rising consumption. And certainly in the British case the ISEW shows a steady fall in our standard of living since about 1970, as opposed to the steady rise in our consumption of goods and services.

The world's present unsustainable economic system is the direct result of very cheap fossil fuel. We have confused capital with income. We have treated the once-for-all, non-renewable endowment of fossil fuel as if it were a flow of sustainable, renewable energy. But the days of very cheap oil are numbered. Perhaps 40 years of relatively cheap oil remain. It seems that world oil production may continue to rise over the next 10 years (to some 24 billion barrels a year) and then fall steadily to 5 billion barrels a year by 2050. (Who will decide who gets how much?)

The Middle East alone is not near its production peak. In about 10 years it will be providing about 50% of world output - and getting close to peak production. World oil prices could easily increase five-fold during the next 20 years. Increased coal production could give some countries an extra source of fuel. But if we want to protect our children and their children from some very severe economic shocks, we would intensify work on renewable sources of energy, and ways of conserving energy without delay.

Agriculture

Whereas sustainable forms of energy are only just beginning to emerge - and we may well regret how slowly - much better progress is being made with sustainable agriculture. Most of the progress, it is true, is being made in poor countries; but within the past few years organic agriculture - the sustainable form of husbandry - has also made some progress in Europe.

During the past 50 years agriculture in the industrialised countries has become increasingly dependent upon oil, both for its machinery and also as the source of chemical fertiliser, pesticides and herbicides. This is an unsustainable form of agriculture not only because oil is on its way out, but also because of the disastrous environmental effect of chemical agriculture: it is bad for biodiversity, bad for the living soil, bad for drinking water, and it cannot be good for people, especially babies. Even if chemicals are not used, marry practices of Northern (European and American) farming are inappropriate for farms in many developing countries, especially Africa. These practices include tree clearing, deep ploughing and mono-cropping.

Work at the Mbita Point Research Station on the shores of Lake Victoria in Kenya represents some decisive steps towards sustainable agriculture. In East Africa, maize faces two major pests. One is the stem borer, which generally reduces the crop by one third. But the stem borer is even more fond of napier grass. This lures stem borers away from maize - and into a sticky trap which kills its larvae The second major pest is striga, a parasitic weed But another weed, desmodium, repels striga. These low-cost "technologies" have spread rapidly in Africa and have now reached Ethiopia.

Other techniques include replacing chemical fertiliser with compost and animal manure, crop wastes and nitrogen-fixing plants, and also the introduction of natural insect predators. These examples and many more come from a major study recently completed by Jules Pretty of the University of Essex in England. It is the largest study ever made of sustainable agriculture; it analysed more than 200 projects in 52 countries. It found that more than 4 million farmers, covering an area the size of Italy, are using sustainable techniques with average increases in crop yields of 70 per cent.

Modern chemical farming is not the most productive. Miguel Altieri of the University of California at Berkeley says: It takes 1.75 hectares planted with maize to produce as much food as one hectare planted with maize, squash and beans. This is because of the reduction of losses caused by weeds, insects and diseases; and a more efficient use of water, light and nutrients. Monoculture breeds pests and wastes resources.

It seems that GM crops have nothing to offer compared with sustainable agriculture. For example, a group working in Madagascar were looking for ways to increase rice yields on small farms. They decided to use local strains of rice, not "super-rice" strains. A local catholic priest, Henri de Laulaine, by trial and error found a system that raises yields from 3 to 12 tons a hectare. This is done by transplanting seedlings earlier and in small numbers; reducing flooding of paddies; and using compost not chemical fertilisers. This system is now used by 20,000 farmers in Madagascar, and Cornell University has taken the system to China, Indonesia amid Cambodia.

One country, Cuba, has switched entirely to sustainable agriculture. After 1990 Cuba had to use low input agriculture or starve (the former Soviet Union used to supply Cuba with seeds, tractors and agro-chemicals). Today, Fernando Runes of Cuba's *'Pasture and Fodder Research Institute'* says that teams of oxen replace tractors and farmers use organic methods along with maize/bean mixtures; now yields have doubled and calorie intake per person is back to pre-1990 levels.

In many countries, the end of ploughing has been an important step towards sustainable agriculture. Ploughing is not good for fertility and causes erosion. Today one third of Argentinian farmers don't plough, and keep down weeds by such methods as planting winter crops.

Zero tillage also benefits the planet because unploughed soil retains carbon.

Sustainable agriculture offers huge benefits to small farmers in developing countries - and to farmers in the industrialised countries too. Especially after the Second World War, countries such as Britain rushed headlong into agro-chemicals in pursuit of cheap food.

But people are now beginning to listen to the *'Soil Association'* arid the '*Henry Doubleday Research Association'*, who for many years have argued that healthy food – organically grown – is more important than cheap food; and that farmers have other duties to society that they can only discharge by adopting sustainable methods. These include, besides unadulterated, healthy food, the maintenance and improvement of soil quality; a pure water table; biodiversity including genetic variety; and strong arid prosperous rural communities.

No one could seriously dispute the report's central conclusion: namely that the only real hope for the world's poor is to raise farm productivity in developing countries by adopting sustainable agriculture; raising food output by using low-cost, locally available technologies and inputs, appropriate technologies.

I will conclude by drawing your attention to another report published more than ten years ago, which should be read along with the Jules Pretty study. This is Africa: The Urgent Need for Tree Planting' by R. D. Mann, 1989. In this remarkably well-informed and persuasive work, he argues, for example, that tree-felling and 'modern' farming practices have led to drought and dust storms in Africa. Dust - topsoil, not sand - fallout across the Atlantic from Africa, measured at Barbados, increased from 6 microgrammes per cubic metre in 1966 to 15 in 1972, and 24 in 1973. The report describes in detail the consequences of removal of tree cover and the planting of cash crops such as groundnuts that leave no ground cover post harvest. The results are falling water tables and less rainfall.

Agro-forestry, incorporating trees into farmland, makes a major contribution to sustainability, primarily because trees create windbreaks, control soil erosion, improve soil fertility and soil structure. Examples show that crops planted under acacia albida increased by nearly 60 percent. Maize yields rose by 76 per cent, and sorghum by 36 per cent.

Zero and low tillage greatly improved soil quality. Mulching reduced ground temperature. Soil organisms cannot survive very high temperatures such as 50-65 C, common on bare ground. Bob Mann's work in West Africa has resulted in the establishment of many tree nurseries. Fast-growing trees such as grapefruit, jack fruit, mango, guava and cashew have proved very popular as ground cover and for avenue planting of food crops.
I commend these two reports, by Jules Pretty and Bob Mann, to anyone interested in sustainable agriculture. It is of course impossible to do justice to them in such a brief survey but between them, they demonstrate, beyond any shadow of doubt, that sustainable agriculture is very necessary, possible, and has the future on its side.

A New Approach to Development by George McRobie

Because most poor people in the world make a living by working on small farms, in small family businesses or as artisans, technologies appropriate to their needs and resources will generally be small, relatively simple, inexpensive arid (to be sustainable) non-violent towards people and the environment.

But experience has shown that it is not by any means enough to produce and field-test such technologies. Devising or adapting the right hardware is part of a package which includes identifying the specific needs and resources of tile community; developing a technology that can meet their needs - that raises their incomes on a sustainable basis; and getting the technology widely Introduced under operating conditions.

Obviously, to be appropriate the technology should be capable of local operation and maintenance, and local or at least Indigenous manufacture; it should be owned and operated by its users, and result in a significant increase in their net (real or money) income; it should utilise to the maximum extent local and renewable-raw materials and energy, and it should lend itself to widespread reproduction using indigenous resources and through the medium of local markets.

The growth of indigenous voluntary agencies in the developing countries is one of the reasons for a major shift towards decentralisation by the *'Intermediate Technology Group'*. It has recently set up seven country offices, under local staff in Kenya, Zimbabwe, Sri Lanka, Peru, Sudan, Bangladesh, and Nepal.

The first four of these are regional offices between them covering Africa, Asia, Latin America. These centres are intended to become increasingly independent of the parent body in Britain, and start work in other countries. Thus decisions about appropriate technologies will be taken, as they should be by people in the developing countries. Here is a summary of the Group's current activities in different countries:

- Bangladesh: agro-processing and textiles;
- India: inshore fisheries, textiles, and household energy;
- Kenya: transport, stoves, building materials, and animal husbandry;
- Nepal: micro hydro;
- Peru: agro-processing, mining, building materials, micro-hydro and irrigation;
- Sri Lanka: rural workshops, transport, stoves, and agricultural processing
- Sudan: food security
- Zimbabwe: transport, mining, agricultural processing, building materials.

Today, thanks chiefly to the work of the Group, appropriate technologies are available over a wide range of human activities, especially those related to basic human needs. Small-scale, low-cost technologies exist in, farm equipment and food processing, water supply, building materials, textiles, small-scale manufacturing, energy, transport.

What is beyond question is that technology choices can now be created for all practical purposes across the board. When high-quality engineers turn their minds to devising small-scale capital and energy-saving technologies, they can produce some remarkable results. Here are a few examples of what is being done.

In a project in the Sudan, small farmers doubled their production of using donkey-drawn ploughs and carts. Because technology alone does not create a strategy for sustainable agriculture, and better livelihoods the Group introduced a package of changes increasing the amount of cultivated land ('donkey-ploughs'); reducing the risks of rain-fed cultivation (terracing); and improving non-farm skills and income opportunities (processing, storage, marketing). Environmental and social improvements are an integral part of sustainable agriculture.

IT Peru runs a major work programme including agro processing, energy (solar and hydro) and irrigation. They employ many technical specialists and the group raises most of its own funds internationally.

IT Zimbabwe's work on appropriate building materials such as stabilised soil blocks and micro-cement roofing tiles has reduced housing costs by up to 30 percent while improving quality. Locally made brick presses cost half as much as imported ones.

Another project is to help poor urban dwellers to generate new incomes for their housing; welding, processing peanut butter and brick making are proving, successful; so are tool hire and honey production.

Seed fairs help to spread knowledge of appropriate crop varieties and so add to food security. Work on small-scale mining includes a project to equip women with the technical, financial and management skills needed to run mining businesses.

IT Sri Lanka's programme includes micro-hydro installations and it is becoming a centre for fostering decentralised renewable energy options for Asia. It works on solar energy, methane gas, and also cycle-based transport. Cycle trailers are made in small rural workshops, and credit schemes help people to buy cycles and trailers. TSL has successfully lobbied to get rural transport recognised in government transport policy. It has also influenced government to allocate 10 million rupees to develop intermediate forms of transport in the country.

Educating policy-makers is now firmly on the agenda of '*Intermediate Technology'*. Technology choice is by no means always left to people in local communities. Government policies, international agreements and the pressure of big business often work t to the disadvantage of poor people in poor countries. For instance, donkey, carts and ploughs can greatly benefit poor farmers. But all the benefit and more can be wiped out if agro-businesses in rich countries control the supply of seeds; or if governments of poor countries are persuaded to choose big dams (which often benefits contractors in rich countries) instead of small-scale hydro systems that benefit local industries and communities.

'ITDG' is now increasingly involved in advocacy - of the kind that recently changed policy on hydropower in Nepal, in favour of small- scale hydro. This appropriate technology option had been ignored until the Group was able to demonstrate that big dams were not the right answer, either economically or environmentally.

The Group is currently involved, in partnership with many other voluntary organisations, in a campaign to ensure that access to genetic resources for food and agriculture remains free and open, and not restricted by intellectual property rights or other devices favoured by rapacious big business in the rich countries.

Today *'ITDG'* employs some 400 staff; 300 of them are nationals of developing countries working in the regional or country offices of the Group. The IT Group also has three trading subsidiaries.

- *'ITDG Publishing'* with 4,000 titles, a bookshop in London, and book voucher schemes for developing countries
- '*IT Manufacturing'* in Zimbabwe, providing tool hire services for small businesses
- *'IT Consultants'*, which undertakes consultancies on a commercial basis for governments industries, voluntary bodies and international organisations. Last year it earned more than £I million towards the Group's total income of £13 million.

One of *'IT Consultants'* success stories is a solar lantern for household use which it has recently put on the market (it may prove to be as popular as the now famous clockwork radio). With inventions such as these, the Group's extensive and expanding inventory of appropriate technologies and its role as an advocate of appropriate technology - based on an impressive track record - firmly established, the Group is helping to turn sustainable development from a forlorn hope into a promising practical reality.

A New Renewable Energy Infrastructure as the Instrument of Radical Change by Jackie Carpenter

This paper argues that the development of a secure sustainable energy system can be the instrument of change: a practical, active, radical path to a new and better future. Regardless of political ideologies and structures, whatever happens about food, water and health systems, whether money and taxes are radically changed or not, the future well-being of people will depend on investment in a renewable energy future.

The investment needs to be of two kinds: investment in hardware so that machines and devices to harvest and store energy are manufactured and installed while we yet have the materials and the capability. But even more important will be investment in local knowledge, so that in future, local communities have access to information that will enable them to build and maintain windmills and watermills, hot water and heating systems, transport based on electricity and energy crops, and local electrical distribution systems.

Without a human-scale renewable energy system in place, radical changes will lead to a primitive existence with no prospect of a high quality of life.

Many people dream of a future in which individuals become more empowered – not because they have won the lottery and can suddenly call the shots, nor because they have worked hard and with brilliance until they have become one of the captains of a multi-national – but because we have all become more empowered. The dream is of a future where 'they' listen because 'they' are friends and people we know in our local community and neighbourhood rather than faceless leaders and bureaucrats in some distant unknown centre such as London, Brussels or New York.

These people have a vision in which the world is a beautiful place again, with clean air and clean water. They imagine our children, healthy and strong, playing happily out in the sunshine with no fear of injury. They envisage wonderful, tasty, nutritious food grown amongst beautiful landscapes teeming with wildlife. Local people in this dream will develop local customs that suit them, educating their children in what is important to them. Farmers, craftsmen and artisans will weave their own creative inputs into the fabric of their society and here and there surges of creativity will create wonderful buildings and works of art to rival those of past ages.

Sometimes it seems as though everything is moving in the opposite direction to this dream. Society is heading towards a global system; the internet weaves its spider web into every home; world trade advances inexorably; technology becomes so complicated that no one person understands it. The ordinary people feel totally powerless, whether they are poor people suffering from hunger in the third world or well-off middle-class people suffering from frustration in England. They lack any sort of power to make the future as they would wish it to be.

Every person is born with the wish to control their own destiny. It is part of the human condition. Voting for some leader every three years or so is not sufficient, if the voter is not able to make his own day-to-day decisions. Having voted, he does not wish to relax and leave it all to the wise leader. Even a two-year old, inexperienced, knowing little, feels that he knows enough to decide what he wants and will not be happy to leave it all to his parents. And as adults, we know that we know more about our local conditions and certainly about our own dreams and wishes than our elected politicians do. The feeling of stress and unwillingness to accept decisions imposed on us increases as external difficulties increase. So it is increasing now as the world heads into the most severe global crisis ever.

These internal tensions are a natural part of any dynamic system. Observe a set of oil globules poured into the surface of boiling water. (If the spaghetti is about to boil over, it is a common trick to pour on some vegetable oil to break down the surface tension.) The oil globules start to coalesce, two join to become one bigger one, the largest one swallows smaller globules round the edge and then, just as the whole drop of oil seems about to become one, the tensions within become too great and the oil shatters into a thousand droplets. This seems to be the way of human societies and organisations – they grow and then break down. The fact that we are on the verge of attaining huge global systems surely heralds the breakdown of nations.

People are aware of the tension and feel fear. Global warming and climate change seem to many to offer the biggest threat ever faced by mankind. There are floods, storms, wild unpredictable weather. Population growth, coupled with the certain knowledge that we are using up the storehouse of raw materials that the earth once had, paints a dire picture.

The rate at which we are converting raw materials into rubbish almost defies belief. Imagine the ten million mobile phones in the UK going into landfill sites every three or four years as the fashions change? Imagine six thousand million mobile phones going into landfill every few years if everyone in the world achieved the level of owning a mobile phone? And all the other gadgets and cars and machines and clothes and furniture as all our raw materials are converted into rubbish at a truly alarming rate.

Meanwhile, animals are becoming extinct and even the bountiful seas are becoming empty of fish. The economies of the world, largely theoretical, based on money as a commodity that does not really exist but that is manufactured by banks without restraint or logic, suddenly seem set to fail. Illness in animals as well as in people expands all the time; far from scientists and doctors curing or preventing diseases and money spent on illness becoming a thing of the past, the budgets for the Health Service (really the 'Illness Service') increase alarmingly.

People in large numbers feel forced to strive for greater and greater personal wealth and power to offset their fear, and in their way contribute to the growth preceding the breakdown.

Some seek more powerful armies, but armies cannot fight the demons that we are fighting in these times. They add to the chaos as they fire depleted uranium bullets into the environment and stockpile horrific chemical, nuclear and biological weapons. They compound our fears, the weapons of our own armies becoming more of an enemy that any human enemy could ever be.

Some seek to gain maximum power so they can exploit the weak and those far away in distance or in time. They steal from their grandchildren or take more than their share from the poor countries. They work towards becoming part of the powerful centre, taking taxes and profits from others, manipulating the laws to keep themselves in power. They use immoral instruments such as usury, advertising and market forces to increase their power. They imagine that science and technology can find a solution to everything and that, at the last resort, they will be able to use space travel to escape (although where they think they will be able to find a destination that can compare with even a ravaged earth is unclear.)

But others look to a different set of ideas that will provide solutions to their fear of the future. The problems are increasing; the fear is growing; and as it does so, this type of solution is increasing at the greatest rate. People build a cushion for their insecurity by buying into local self-sufficiency.

They go to the farmers' market to buy food. They know if there is a fuel crisis and the lorries cannot deliver food to the supermarket, it will be good to have a farmers market. They support their local village school, and campaign and fight to stop the small post office being shut. They may not feel very religious but they go along and support the vicar's coffee mornings because he is doing a good job for the neighbourhood. They have a feeling that supporting the multinationals is not a good idea and they start using their local credit union and even think about taking all of their money out of the Big Banks. After reading about the banks obscene profits, no one is obliged to use them. Even a small unimportant person can wield a little power.

This wave of local empowerment has started and cannot be stopped although none of the central institutions wants to encourage it. The Government thinks it is not democratic, because surely democracy means voting for a central government to do what is best? The multinationals and big supermarkets either arrogantly dismiss the wave or try to enforce regulations that benefit large organisations. They know they have more power over the governments than the people themselves.

They use their great powers to try to maintain the status quo, appealing to the basest emotions of humanity. Marketing appeals to people's greed or to their fear of not being wanted. Advertising tries to make young people think that appearing cool, trendy and fashionable is important but although many are taken in, a great many are not. Most people know in their hearts that duty, responsibility, loyalty and morality are the qualities to be admired, whatever the adverts say. They know that love and happiness are the true goals, not fast cars and trendy clothes and furniture.

And so the little people go about their business quite oblivious to what those in power think they should be doing. I can grow my own vegetables in my garden. No-one knows. My vegetables are not part of a food statistic. I can heat my water using the sun and then my kilowatt-hours will not be part of the economy. I can trade in LETS and only earn a little cash so that I stay below the tax threshold but claim no benefits. I can develop a wide set of friends and local acquaintances and set up a help network, so that we are always there to help each other. I can be a little mouse, running about on the forest floor while the huge dinosaurs of government and big businesses go about their business above my head. If there is a breakdown of the large human institutions, will I even notice?

If we do start to experience a breakdown of our twentieth century way of life, the world could become an unpleasant place, at least in the short-term. It could rapidly become a place in which wads of money and mobile phones had no value at all. In the worst analysis, it could become a terrifying world of war, even civil war, plague, pestilence, famine, violent storms, floods, earthquakes, poisoned water, radioactivity and police states.

These scenarios are at the back of everyone's minds, especially after the diet of fiction we have all been fed for decades in the form of exciting films and paperbacks. Perhaps because of this fictional influence, many people at present are laughing off their fears as if they were fiction, even if they experience them deeply at the sub-conscious level.

Despite these fears, many optimistic people believe that the way forward from our present unsustainable way of life to a far more pleasant world could be enjoyable and positive, especially if it involves increasing empowerment at the local level as the changes come about. People enjoy rising to challenges and a common experience is that working together in the face of a calamity strengthens the bonds of local communities. Almost by definition, the breakdown of the control of human activities by large, powerful central institution cannot be organised by large powerful institutions.

I believe that the dinosaurs will gradually but surely die and the mice will come into their own, masters of the world. It is interesting to observe that multiple, small things are often a force for good compared with a single comparable large thing. Compare the beneficial power of trillions of raindrops with the destructive power of a tidal wave.

The aim must be to arrange for a positive path forwards during the breakdown of the unpleasant aspects of the old world order and the building of a new world. Building the basic infrastructure for the future need not just come about as the result of change: it can be the instrument of change, the practical, active, radical path. At the same time, the decommissioning of all large, polluting industrial plants will provide employment for many years to come and be seen as a dynamic mission. It is akin to the work of cleaning up after a reckless party and tidying the house ready for a period of pleasant living.

And the living will be pleasant if we achieve a basic set of building blocks on which to establish our future. The basic human needs are well understood, and they do not include the need for vast amounts of materialistic and fashionable goods. People need water and food, then shelter and warmth, then human companionship and culture, then higher creative aims.

Local food systems can be re-established now, even if it takes decades for them to come into full productivity. Loss of local know-how in crucial industries such as cheese-making needs to be re-gained. Meanwhile a steadily diminishing amount of world trade can help to feed people until the adjustment to local food has been made. Despite globalisation, in most localities a local infrastructure for rudimentary health, shops and education still exists and can be re-developed. There are local builders and craftsmen, people who can mend and make things. Even if the money system were to break down entirely, people would find ways to barter and trade, as human beings always have.

But to go from our present way of life to this new future offers a major problem in one area. How can we secure the energy supply that we need for quality lifestyles? Back in the dim and instant past, before coal and oil came into use, people lived at a primitive level and used very little energy. Not surprisingly, we fear the idea of becoming primitive again, of going back to the cave. Electricity is a wonderfully convenient invention and without it we cannot even have lights in the evening, let alone computers and all the amazing household appliances we have invented. And how can we travel without an energy supply? It may be that our aspirations for technical gizmos diminish as we regain our sanity and our sense of place within nature, but there is no need to plan for a totally technology-free world. The best way will be to identify appropriate technology that can co-exist in harmony with nature, and to use our undoubtedly technological human brains to find ways that make our lives easier and less of a chore without damaging the ecological systems around us.

Nature is bountiful: the sun beams 15 000 times as much energy to the Earth as is used by humankind. Oil and uranium are at the root of our problems. Energy originating from the sun must be at the root of our solutions. So perhaps the most important immediate consideration is to actively build a reliable energy infrastructure as soon as we possibly can, before any possible breakdown begins to occur. We have more wealth than any set of people has ever had in history, and we could use this wealth to secure the energy resources that we need for the future. The energy supplied by the mega-utilities that comes along cables from large nuclear or coal power stations hundreds of miles away is not exactly inspiring in its reliability.

Even without any idea of the large companies failing, they regularly fail to provide power, at least in some rural areas or in severe storms. If the weather is going to become worse and the future more uncertain, then local self-sufficiency of energy is a very sensible strategy.

Although the Government, by virtue of its need to maintain central power to ensure its own survival for as long as possible, would not normally support or help an idea such as local energy schemes, surprisingly enough, it is beginning to support them with increased vigour. It is supporting renewable energy because of the threat of climate change, not because the systems are small. It supports the idea of obtaining energy without increasing the carbon dioxide burden, which the scientists say is now a real threat and the politicians perceive may become a sudden threat to votes.

Renewable energy is now a firm part of the Government's policy for sustainable energy, in fact the central part. The main schemes being supported are offshore wind farms and fairly large biomass power stations, because these are almost part of the status quo. This is unfortunate because a large offshore wind farm will not be much use if the global crisis leads to a breakdown.

However, because renewable energy schemes are by their very nature small and local, the Government is also finding itself supporting the idea of photovoltaic roofs on the houses of citizens and new schemes for embedded generation so that electricity can be exchanged with other users over a local network. These smaller schemes bode well for a small-scale future. The number of small plants is now increasing rapidly, with small hydropower schemes on rivers, local wind turbines, and small combined heat and power plants running on wood that produce heat as well as electricity. There are other heat collecting systems such as simple arrays to produce hot water and heat pumps to make use of warmth in the ground or river. New forms of energy crops are being planted as well as more traditional forests.

There is a now a race to develop better ways of storing energy, whether in the form of heat, electricity, hydrogen or new types of battery. Renewable energy stations are not like the old power stations which begin with a huge pile of energy (in the form of a stockpile of coal or uranium) and the aim of converting it into power. Renewable energy stations begin with the aim of collecting energy from the environment, energy that comes from the sun and manifests itself as the energy in weather systems or already stored in plants or animals. Once collected the energy must be stored to use later and then it needs conditioning to bring it to the form that people need.

Developing and maintaining the knowledge about these technologies is a very important aspect. The technologies are not large and awesome and impossible to the majority to understand, like nuclear power stations. Most people, with simple training, can learn how to connect generators to batteries and inverters. They can understand how to install and maintain a small hydropower turbine. They can fit solar hot water systems to their own roofs and can plumb them in to their own water tanks. This knowledge and understanding is key to quality of life in the future, as inheriting the hardware without the knowledge will not be sufficient. But a good understanding of energy technologies at the local level will ensure that a good quality of life will be possible in the future.

A secure and widespread renewable energy infrastructure is necessary to form the basis of a sustainable future, in which our energy supplies are produced in harmony with nature from the natural energy flows through the environment. Being widespread, local and diverse, this energy basis will tend towards an equitable and secure society, with local employment generated by people's energy needs. The local community will be empowered to make choices about the source of its energy supply: whether it prefers a set of wind turbines or the growth of more energy crops, for example.

I believe it is inevitable that future human societies will use renewable energy as their main source of energy for two reasons: because uranium and fossil fuels will not last for ever and because uranium and fossil fuels can only be used for so long before the environment is damaged beyond repair. Renewable energy as the basis of future society seems the one fixed certainty in a time when the prediction of the future is so difficult.

If the transition of society takes place in an ordered manner and central government and large companies continue to dominate the world even as renewable energy is introduced, then the investment of our present wealth into the new systems will still have been the wisest investment that humanity could have made.

But if the great globule shivers and breaks up into thousands of small droplets; if the dinosaurs keel over in their final death throes; if the mice come running out of the forest to inherit the world; what then? Then the energy systems will make the difference between a poverty stricken society based on human toil with no convenient technology to ease the burden, or a bright new solar future.

Human Scale Energy for Gloucestershire by Jackie Carpenter

Some people think that renewable energy is too costly and that the idea of 100% renewable energy is impossible. The purpose of this paper is to open people's eyes to the value of the energy that is used in the county of Gloucestershire, and to the fact that a 100% supply is achievable.

We have carried out research to identify the amount of energy that is used each year in Gloucestershire. Using the information that the population of Gloucestershire and the energy use of Gloucestershire are approximately 1% of the UK figures (DTI), the approximate answer is 15,000 GWh/yr.

There are only one or two very small renewable energy installations in Gloucestershire so nearly all this energy is imported from outside the boundaries of the county. *(The figures given in this paper are in gigawatt-hours (GWh). One unit of electricity, as shown on electricity bills, is* one *kilowatt-hour. A gigawatt-hour is a million kilowatt-hours i.e. a million units.)*

The value of each unit of energy is a difficult question.

Domestic electricity can be as much as 8 p per kWh but gas for industrial use can be less that 1p per unit Present prices are dropping because the regulators are forcing more competition but in future, especially as conventional fuel supplies start to run out or as more carbon taxes are introduced, the prices may rise rapidly. For this estimation, 3 p/kWh is used.

The value of the energy used in Gloucestershire is therefore 15,000 x 1,000 x 3 which is approximately equal to half a billion pounds per year. If all the energy needs of Gloucestershire could be satisfied locally instead of being imported, this represents an amazing boost to the local economy. Half a billion pounds a year, every year! No other imaginable economic change could result in this sort of improvement to our local wealth.

The amount of energy reaching us from the sun in Gloucestershire is on average 2.7 kWh per square metre, every day. This comes to about 1 000 kWh per square metre per year. Multiplying by the area of the county, the amount of energy that we receive each year is 2,600,000 GWh per year - nearly 200 times as much as we use. This natural energy causes plants to grow and gives rise to the energy in the weather.

There is additional energy available to Gloucestershire from the River Severn, so there is plenty of natural energy to support a total renewable energy supply.

A more ambitious target would be for the county to become a net exporter. Many technologies exist to collect this energy and the challenge of collecting less than 0.5% can surely be met

The following pages give just one possible scenario worked out very simply without details about storage, distribution and economics. The strategy could give a massive boost to the local economy, providing local jobs, wealth and security. The best strategy will be to develop renewable energy extensively before the fossil fuels start to run out. Other countries are rising to the challenge and the UK will eventually follow. We have the technology! Do we have the will?

GLOUCESTERSHIRE STATISTICS

LAND USE *100 ha = one square kilometre*	**NOW** **hectares (ha)**
Urban	17,000
Woodland	22,000
Forest of Dean	*11,000*
Private/Local Authority Ownership	*10,000*
Agricultural	209,000
Grass	*100,000*
Crops and Fallow	*80,000*
Set Aside	*20,000*
Farm Woodland	*10,000*
Energy crops (SRC)	*24*
Other	12,000
Total	**260,000**

PEOPLE AND HOUSES	**NOW (1999)**
Population	541,000
Households	211,670
Total Dwellings	222,328
Approximate number of cars	231,000

GLOUCESTERSHIRE'S CURRENT ENERGY USE

Energy is currently delivered to the consumer as (figures in GWh/yr):

Coal	**Oil & Petrol**	**Gas**	**Electricity**	**Other**	**Total**
700	6,700	4,500	3,000	100	15,000
5%	45%	30%	20%	<1%	

The current energy split between the following sectors is (figures in GWh/yr):

Transport	**Domestic**	**Agriculture & Industry**	**Commercial & Services**	**Total Demand**
5,250	5,250	3,000	1,500	15,000
35%	35%	20%	10%	

At present renewable energy sources only supply around **150 GWh/yr** or **1%** of the County's energy. Targets for the future use of renewable energy include the EU's target of 12% of all energy by 2010 and the UK Government's target of 10% of electricity by 2010**.**

GLOUCESTERSHIRE'S FUTURE ENERGY - A SCENARIO

Grey boxes give facts and figures. White boxes give a possible scenario.

Energy use of the sectors reduced by good technology (figures in GWh/yr):

Transport	Domestic	Agriculture & Industry	Commercial & Services	Total Demand
2,700	4,200	2,000	1,400	10,300

Wind Power

Turbine	Blade diameter (m)	Output (GWh/yr)
Very small	0.5	0.0025
Large	40	1.25
Very Large	60	3.5

Turbine	Number in Scenario	Output (GWh/yr)
Very small	240,000 (one per house)	600
Large	2,600 (one per sq km)	3,250
Very Large	100	350
	Total	4,200

PV

The average yearly insulation in Gloucestershire is 1000 kWh/m^2/yr. PV can collect 10% and the average available domestic roof area is 12–20 m^2 per dwelling. PV could also be installed along the edges of all roads or covering brown field sites in urban areas.

If a future scenario has 240,000 dwellings, then PV installations of 20m^2 on ALL dwellings could provide 480,000,000 kWh/yr or 480 GWh/yr. Installing PV systems on all *current* commercial and public buildings could supply 30 GWh/yr. One ha covered with PV would supply 1 GWh/yr – and the County has 260,000 ha.

PV SCENARIO	Total Output (GWh/yr)
All dwellings with 20 m^2 of PV. Assume 240,000 dwellings. Commercial buildings and roadsides	480 60

Biomass

Short Rotation Coppice (SRC) has an energy yield of 70 MWh/ha/yr – there is a wait of three to four years from planting until the first harvest. Forestry thinnings provide 12 MWh/ha/yr.

All current set-aside (20,000 ha) planted with SRC would give an output of 1,400 GWh/yr. Forestry thinnings from all the forests in Gloucestershire (22,000 ha) would give 264 GWh/yr

BIOMASS SCENARIO	Total Output (GWh/yr)
50,000 ha of short rotation coppice 10,000 ha of forestry thinnings	3,500 120

Hydropower & Tidal Power

In Gloucestershire there are approximately 20 easily developed small-scale hydropower sites with capacities over 20 kW and 5 sites with capacities over 50 kW. Despite the fact that there are no *readily accessible* sites with capacities over 100 kW, the total existing resource is of the order of 2 MW, possibly 5 MW. The maximum energy from this resource is calculated by power x number of hours per year x availability x efficiency = 5 x 8760 x 40% x 80% = 14 GWh/yr

An 8600 MW tidal barrage across the Severn Estuary could provide 17,000 GWh/yr and would take 10 years to build. A series of small tide mills could provide say 100 GWh/yr. Underwater turbines can make use of the energy in tidal streams or currents.

HYDROPOWER & TIDAL SCENARIO	**Total Output (GWh/yr)**
Hydropower as above	14
Combined tidal and underwater turbines	1,500
Severn barrage	no

Energy from Waste

Waste production in Gloucestershire amounts to around 1tonne per capita per year. (This figure may change in a future scenario.) Each tonne of waste could produce 550 kWh.

Total waste in 1999 was 541,000 tonnes - a potential 297,000,000 kWh/yr or 297 GWh/yr.

ENERGY FROM WASTE SCENARIO	**Total Output (GWh/yr)**
One tonne per person, assume population up to 550,000	303

Other

One 4 m^2 domestic solar hot water installation can provide 1250 kWh/yr.

OTHER	**Total Output (GWh/yr)**
All 240,000 dwellings with solar hot water	300

Technology Type	**Energy Produced**
Wind Power	4,200
PV	440
Biomass	3,620
Hydropower	14
Tidal & current	1,500
Energy from waste	303
Other	300
Total	**10,377**

November 1999 with a few minor changes August 2001 Jackie Carpenter, Energy 21

"RE-thinking" by John Stringer

Towards a Sustainable Energy System

There are various ways to think about the future, but where issues are long term, and must mean eventually abandoning much that is familiar, "muddling through" by making disjointed, incremental, changes for short-term reasons is a reckless gamble. Near-term decisions have long-term impact. The sensible approach is to look forward, beyond the lives of existing assets, and design a desirable future and then to seek feasible ways to bring it about. Decisions can then be guided by a *vision*. This is especially needed for the transition from fossil fuels to renewable energy (RE) sources (RES).

Energy comes now from bulk fossil and nuclear sources (mines; oil and gas wells; power stations; refineries), and is distributed by electricity and gas grids and by tankers. Concentrated production brings economies of scale, but also remoteness from points of use. The flow is *"Few to Many"*.

By contrast, many RES are small and dispersed, and better suited to a *"Many to Many"* flow pattern in which capture, conversion, and storage of energy take place close to the points of use. Economies can be sought through volume production of the relatively small items of equipment required.

Fundamentally, demand is not for energy *per se* but for benefits it brings in comfortable living, goods production, transport and communication, etc. Rising population and rising aspirations are increasing world demand for these benefits.

Studies show that sufficient energy to provide them *could* be obtained without recourse to fossil fuels or nuclear power. It can be done with known RE technologies and efficiency practice, but it may take half a century to replace existing energy assets with equipment appropriate for a sustainable energy system.

Careful *systems design*, matching sources to uses, will be needed; renewable sources have to become *cost-competitive*; and there are resistances to be overcome, not least by the messages carried by clear and well-informed *policy*.

Systems Design

The characteristics of many of the RES suggest a system composed of "local energy cells" (LECs) each serving a neighbourhood or small town and substantially self-sufficient in energy. The components of each LEC would, depending on local circumstances, include:

- Primary energy sources…e.g. roof-mounted photovoltaic & thermal solar panels; nearby bio-energy crops and agricultural and forestry wastes; wind turbines; small-scale hydro
- Means of conversion from one energy form to another…e.g. bio-fuel fired combined heat and power (CHP) plant; hydrogen production by electrolysis
- Means of storage and recovery…e.g. as hydrogen; in electro-chemical batteries; as warmth or "coolth" exchanged with sub-surface strata by ground-coupled heat pumps
- Distribution networks…low voltage electricity; hydrogen; hot and chilled water
- Appliances located where ultimate needs for warmth, light, transport, manufacture, etc. are met …including fuel cells (mainly to power road vehicles but also for stationary appliances); micro-CHP turbines (to provide heat and power for individual houses and other buildings); heat pumps
- Means of control to ensure stability, reliability, and economical operation.

Since supply and demand are unlikely to be exactly matched within every LEC, and also for reliability, some linkage would be needed between adjacent LECs and the electricity grid would thereby revert to the role it had when introduced in 1926, that of providing mutual support for adjacent local systems.

A system of self-sufficient LECs would, however, not suit sources, such as wave-power and offshore wind, located in remote areas. How, then, could energy from them best be utilised? Electrical transmission to load centres is not the only option.

Substitutes will be needed for oil and natural gas, hydrogen is the only serious candidate and it could be produced, by electrolysis or direct photo-chemical conversion, anywhere between the energy source usage points. High-pressure pipelines are an economical means of transmitting energy and, incidentally, less visually intrusive than power lines.

It is reasonable to conclude that the energy system for a sustainable future must be much more localised than that we have now, that the electricity grid will lose much of its long-distance energy-transfer function, and that hydrogen will be a significant energy storage and delivery medium. This provides a robust conceptual framework within which the optimum size of LECs; the relative contributions of local and remote sources; and the structure of the energy industries, can all evolve.

Evolution will be helped if interim technologies lying on development paths of components of an LEC-based, decentralised, system are used. Replacing coal by natural gas has reduced CO_2 emission from electricity production, but half the energy appears as waste heat. Were conversion to take place at the user end, e.g. using micro-turbines, that heat would be utilised.

Again, hydrogen fuel cell cars may be some way off yet, but weight reduction and hybrid petrol-electric drive can bring big improvements in efficiency and provide experience of technologies needed later.

Cost-competitiveness

Resistance to RES would crumble if they were cheaper than the alternatives.

In the past, development has been driven by *economies of scale*, sought through large units. It is now more appropriate to pursue *economies of scope,* e.g. by combined heat and power (CHP), and *economies of replication*, by mass production of small units of equipment.

Unit cost of an emerging technology typically follows a learning curve such that if the second example costs 85% (say) of the first, then the fourth costs 85% of the second, and so on. Thus a new technology can eventually be competitive but first an "entry cost" has to be paid.

It can be met by niche applications; by companies investing to establish a market lead, or by government support, but if projected eventual savings do not cover the entry cost, the new technology will not be viable without more research and development (R&D). Let us apply this simple model to some RES examples.

Case 1 – photo-voltaics

Photocells are widely applied where they have special advantages, but for general use a fourfold cost reduction is needed. Is this achievable?

R & D is one route. Photocells are now produced from slices of expensive mono-crystalline silicon. Multi-layer cells made from thin films of low-cost poly-crystalline silicon should appear soon. Films of silicon one micron thick, mounted on thin flexible glass in modules a metre square, are expected by 2010. Incorporation in roofing and façade materials offers economies of scope.

Another route is volume production. Detailed feasibility study of a 500 MW per year plant (i.e. rather more than present total world production) has shown it would make photocells, of the present type, cheap enough to be competitive for general use. Multi-billion pound investment in such a plant requires a big increase in the market, but the market will not grow until cost has reduced. If this vicious circle can be broken, by global cooperation, photo-voltaics can soon be cost-competitive.

Case 2 - Cars

Cars are a similar case. Hydrogen fuel cells offer the possibility of a non-fossil source of motive power. The technology exists but there is a chicken-and-egg relationship between production cost and market size. Fuel-cell powered hybrid drive cars would be a big step towards a hydrogen energy system that must come eventually so why expend effort on 'advanced' designs of petrol and diesel engine that only bring minor efficiency improvements? Action on at least a European scale is needed to push the automobile industry and its customers into taking the larger step to RE-powered cars.

Case 3 – Wind-power

Wind turbines are near to cost-competitiveness. NW Europe has a substantial wind resource and, with machines of 2MW capacity now, offshore wind farms become attractive. However, investment is inhibited by refusals of planning consent. Typical UK 'wind farm' schemes simulate conventional power sources in being concentrated and remote, in contrast to the more localised approach in Denmark, where wind-power has penetrated much further. Wave energy, derived from wind, is a huge resource with interesting potential, especially for the UK, but support for R&D has suffered from government impatience with a lack of early returns.

Case 4 – Biomass

Plant material can be burned as solid fuel, or converted to diesel fuel or biogas. Economies of replication cannot be expected in production of the raw material, but there are economies of scope in using agricultural and forest wastes. Since collection area and haulage distance increase with plant capacity, there are *dis*-economies of scale in transport.

But can sufficient land can be spared to produce useful amounts of energy from dedicated energy crops? About 1.5 million people in Kent use roughly 40 TWh of energy a year, whereas if the *whole area* of Kent were available for energy crops, then either 2.9 TWh of diesel fuel could be produced from oil-seed rape, or 2.6 TWh of electricity, plus a similar amount of low-grade heat, from short-rotation coppice. Compare these figures with 9.8 TWh of electricity from 1MW wind turbines spaced at 1km intervals, leaving ground free for crops or grazing, or 299 TWh of photo-voltaic electricity.

Given the unrealistic assumption that the whole land surface is available, these figures demonstrate that the contribution of dedicated crops to energy supply will be small and for special uses.

Case 5 - Time-shift and Storage

Individual RES should not be considered alone but as components of integrated systems, also involving storage and control of energy release, optimised for the particular local circumstances.

Energy will have to be captured from many sources and in many ways, but the time when it is available may not always match when it is needed. In suitable circumstances, and at a cost, energy can be stored in material form as gas, liquid, or solid; as potential energy (pumped storage); as heat, or cold, utilising the thermal inertia of buildings or the ground on which they stand; or in batteries.

Recent battery concepts are promising. In Redox designs, electrolytes are stored in separate tanks and separated in the active cell by a membrane that allows free passage of electrons. Capacity depends only on the size of the tanks, while power output depends on the number of cell modules. Such devices are well suited to mass-production of the basic components. So are hydrogen fuel cells, which, coupled with electrolysers and storage vessels, could serve a similar purpose.

Policy Messages

The UK has responded to global warming more seriously than many, but no government can offer a complete solution to a problem that is unprecedented, global, long-term, and requires co-operation of businesses, professions and the population at large in ways that may not yet be apparent.

If all these decision-makers are to be influenced, policies that impact upon energy need to convey an unequivocal message about energy sustainability. But present policy is a mixture of taxes, obligations, targets, regulations, and financial support and the underlying "vision" is fuzzy. The programme consists of incremental changes to the existing energy system, the focus is short-term and the messages confusing.

After representations, the climate change levy on industry, as proposed, was modified to relieve heavy users, and later to favour RES. Reduced rate of VAT applies to all energy for domestic use, and energy suppliers are regulated with low prices as the aim. Fuel for road transport, but not for aviation, is heavily taxed, all the while espousing a free market economy of which transport is a key component. The regime may encourage investment in efficient vehicles, but not in efficiency and RES for households. The received message is that energy taxation is simply a way to collect revenue.

Support for car plants threatened by closure, to save jobs, sits uneasily with exhortations to leave the car at home. Nor is it made conditional on marketing new types of vehicle. Manufacturing plants need to be set up to produce fuel cells, photo-voltaic cells, micro-turbines, etc. but these do not have the same political urgency. The message is that support is only there to maintain the *status quo*.

The *status quo* is a major consideration in planning and land-use. Planning affects demand for transport and location, design, grouping, and orientation of buildings - all of which influence energy consumption and renewable energy capture opportunities - and scope for energy-efficient design. Development requires cement, bricks, and steel, which are energy-intensive. Such implications ought to be given proper weight in all planning decisions, but that message does not come across.

It has been widely assumed that the grid is the key to a future energy system. Statements about "energy" turn out to be about "electricity delivered through the national grid". In its present form the grid can accept only limited "embedded generation" (the very expression implies that RES should only have a minor role).

Defining the issue as "how to get electricity from RES to feed the grid" deflects attention from making best use of small-scale sources and, while recognising that traditional electricity generation is a major emitter of CO_2, side-steps the fact that five-sixths of final energy is delivered *as gas or oil products*. Consequently, no steps have been proposed towards a hydrogen-based system.

"RE-thinking"

Progress towards a sustainable energy system depends on the extent to which the issues and opportunities are understood and that understanding is applied, as if by instinct. What can be done to instil renewable energy thinking into *all* those strategies and everyday decisions that impact on energy?

One answer is exhortation and education to produce appropriate attitudes and behaviours. But words alone will not do this. To gain proper understanding, decision-makers, professionals and general public must have direct contact with good examples, to the point where these become the norm.

Examples of good practice should be created as local-scale systems and replicated in each part of the country so as to be accessible to everyone. At present the number of examples of, e.g., house roofs equipped as photo-voltaic collectors, is minuscule. Most people simply do not see it as an option.

The greater the number of examples, the harder it will be to dismiss them as impractical. The examples should be demonstrably cost-effective but there is a case for transparent subsidy to enable early display of technologies whose costs will fall to competitive levels once adopted in sufficient numbers.

In particular there is a need to demonstrate complete local systems (LECs as outlined here) and hydrogen-based sub-systems of realistic scale. The latter might, for example, comprise: hydrogen production using renewable energy; storage; use in fleets of fuel-cell powered buses and other route-bound vehicles; and domestic-scale units providing heat and power.

The widespread floods of last winter probably did more, rightly or wrongly, than earlier attempts to bring home to people the implications of global warming. Similarly, practical demonstrations of complete renewable energy systems, sufficient in scale and number not to be easily ignored, are the way to broadcast the now vital RE-thinking.

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Growing Spiritual Food with Natural Energies by Charles & Judith Hubbard

Father Vincent Rossi's excellent article printed in the *'Ecologist'* (Vol. 30, No 1, Jan/Feb 2000, pp 35-39), backgrounds our meagre efforts on "what to do" for revitalizing future smaller farms despite the global and cultural crises. It is indeed a spiritual challenge.

My wife and I started our journey on our honeymoon buying a small farm in North Wales (1960) and then farming full time. Thence - Norfolk and then migrating to Nova Scotia 32 years ago onto our present farms.

Seven children endured this process with large white swine and Jersey purebred breeding stock together with a variety of other animals…especially donkeys. Grains and forages were grown for the stock. I now realize it would have been very beneficial to have initially asked is there a right way to farm? - Or is there a Christian way to farm?

We would not have done what we did if we had…i.e. conventional systems. Later we realized the answers were simple-you either work with nature or subdue nature-either "organic" or "conventional" (chemicals-factory farming) in simplistic terms.

Our Anglican Church life enabled us eventually to understand this as for many years the Rogation Service was and is held on the farm. It was pivotal in determining our present practices.

Briefly the Rogation service held around seeding time here 35 days after Easter involves processing with clergy and congregations to various points on the farm, fields, animals, barns, farm house praying and singing for good crops-the "beating the bounds" i.e. processing around finishing with the Holy Communion. We asked what was all this about? The answer lay with the ancient pre-Christian knowledge that spiritual growth needs spiritual food-not dead food as so much is today.

There is growing awareness, especially in UK, of the importance of placement of sacred sites. Many Churches and Holy sites are built where earth energy magnetic lines cross creating a power vortex. The design involved sacred geometry-rocks or stones carefully selected and tuned so that the whole created an energy field that was a powerful influence for worship. The spire was over the vortex and under this perhaps the altar where the priest receiving this energy from on high was greatly empowered to help his flock.

The energy field created by the whole enabled crops supported with prayer, to grow within this area. The energy field may well have determined what later became known as parish boundaries-hence "beating the bounds".

Thus it is possible that by processing along these energy lines on the farm at this critical time after Easter when there is a surge of heavenly energies flowing from the cosmos-the strength of prayer was greatly increased for the crops benefit.

Beating the bounds defined the energy field of the sacred site of church within which the crops could be affected. It should be noted that with *'Kirlian'* photography the energy or prayer can be seen. Fr. Vincent Rossi's paragraph where he talks of man's divorce from nature is appropriate:

If the root of this alienation of human nature from the natural order is theological, its tragic fruit has penetrated deeply into all aspects of modern society: political, economic, social, cultural and individual. But it is extremely difficult not to envisage even positive activities in terms that remain separating, alienating and abstracting.

By the term 'environment' we usually mean 'the natural world', or, to use religious language, 'Creation'. But if we look critically at the word 'environment', we will sense a certain abstract quality to it. It separates human nature from non-human nature, and turns non human nature into an abstraction – something which we believe can be manipulated and controlled for our purposes.

Even with the best of intentions, we have created and are sustaining a division between the natural world and ourselves – a division that is at the very root of all environmental problems. As Wendell Berry, poet, essayist and farmer, writes: 'Abstraction, of course, is what is wrong. The evil of the industrial economy (capitalist or communist) is the abstractness inherent in its procedures – its inability to distinguish one place or person or creature from another.'

The right scale in work gives power to affection. When one works beyond the reach of one's love for the place one is working in and for the creatures one is working with and among, then destruction inevitably results. An adequate local culture, among other things, keeps work within the reach of love,

The question before us, then, is an extremely difficult one: How do we begin to remake… what will preserve our part of the world while we use it? We are talking not just about a kind of knowledge that involves affection but also about a kind of knowledge that comes from or with affection-knowledge… that is unavailable to anyone in the form of "information".

We bought a 100-acre farm next to our main farm and endeavoured to use this emerging knowledge for farming not just production. We had converted to organic farming previously resulting with our variable costs being greatly reduced along with the stress.

In some mysterious fashion we now have a Traditional Anglican Chapel-the Mission of St. Francis-in our basement-we have weekly services, visitations by our Bishop and various priests for special events and communion.

With the Chapel at the Centre we began to see the whole reality. Now using organic/Bio Dynamic principles, i.e. 1) crop rotations 2) relative livestock, 3) compost, 4) B/D Preps and Earth energies and prayer, 5) other farm resources of flora fauna, we grow grains for stone ground flour-complete livestock rations for many varieties of livestock and vegetables in a self contained system.

We realized that the earth magnetic energies provided us with free energy to create food energy with greater vitality and nutritional balance. This is what we did.

The energy lines were mapped out on the farm by dowsing, which for me was the simplest and cheapest method and provided me with the knowledge to change. Dowsing enables you to use the subconscious for terrestrial problems and knowledge and the superconscious for cosmic knowledge-the universal mind-angelic realm, etc. "If you do not ask you will not receive" is very true.

We dowsed the position for the first big positive wheel-similar to medicine wheels of North America Indian folklore-here four energy lines converged over each other. Not having rocks in the farm to build the wheel, I used a load of granite ¼ gravel because of the high silicate content and 9 ½ tons were placed in 8" trenches outlining the wheel. The size was 28' diameter with 8 spokes equally placed.

The energy field from this one circle was approximately 250 yards. The negative circle position was determined in another field by dowsing. This site had no energy lines initially - the size called for was 17' diameter with 5 spokes unevenly placed.

When this was completed with gravel in tandem with the first wheel an energy field appeared covering approximately 100 acres-with energy lines spreading out all around from the negative circle. At this time we were using a cosmic Pipe. This is a 4'4" pipe in which there is some electronic circuitry.

The pipe was placed on a funnel of energy not an energy line-found by dowsing. It has 8' antennae, which powers the electronics, like a steeple of a church. Inside are put various substances with clockwise spin in little bottles that will benefit the land crops, i.e. compost, sea weed, lime, clover for nitrogen, trace elements, rock phosphate, etc. and outside carefully placed for those ingredients with counter clockwise spin.

The subtle energies of these ingredients are broadcast into the land crops. I change these fall and spring as the energies are depleted. It works. We now place various ingredients also within the segments of the big positive wheel burying then just under the surface and carefully positioned by dowsing, i.e. asking the helpers. These positions are not always the same and change over time.

We now have some very interesting results. The quality of our grains has greatly improved over conventional grains. Of quantity we are uncertain, as it is hard to compare here. A refractometer gives us brix/sugar readings as a guide during the growing season.

I analyse the grains and soils with a radionic analyser that measures the vitality and subtle energies of the various components of the sample-such as NPK, trace elements, amino acids, minerals, deficiencies, balances, etc. Our levels now are 2 to 3 times higher than conventional samples for overall measurements with specifics up to 8 times higher.

Of interest, here there is a deficiency of selenium so young calves, sheep, foals need to be injected to avoid white muscle disease. We have now been broadcasting selenium from the pipe and wheel and now find our selenium levels have risen significantly where we no longer have to treat young animals-a great relief.

Broadcasting the energies from a vial of lime or compost simplifies having enough and is far cheaper than spreading tons of these items. The overall importance again is the nutritional balance achieved with higher vitality than conventional crops, resulting in improved taste and happy livestock who eat less and perform better people too! Our society's present overall health problems are largely due to the wrong way food is produced…this dead unvitalised food.

We are also working on "designer gardens" suited to a person's needs. Within the garden a rock circle is built-carefully sited and rocks selected. Size generally between 4' to 6' diameter with 2 to 4 spokes. Small rocks have to be selected both for circumference and the spokes-with rocks individually positioned and aligned-all by dowsing. The energy field from this one circles varies between 40' to 70'. This can be contained within the garden if you ask. Then certain substances can be placed within the circle.

At present, we have two projects involving chromium for diabetes and calcium/silica for osteoporosis. To date the energies of these have risen appreciably, which could help combating these conditions. It is hardly surprising that diabetes is rampant as one of the causes can be chromium deficiency in our vegetables grown conventionally.

Before the colonialists came to North America, the Indians in the Middle West of USA, using stone circles, created an abundance of food. The colonialists, not knowing about these circles, broke them up resulting in the land becoming rangeland. We have much to learn…only re-inventing the wheel-nothing new.

Thanks to the Rogation Services we began to understand how to work with nature. We believe it follows that if food has a higher vitality then prayer is more effective and thus beneficial for our mental acuity, temporal needs and spiritual needs. We need help from the Churches who need to be well grounded literally. They need humbly-to come close to Earth.

We grow self-baking wheat, which is stone ground, and use this flour for making the communion bread. Compared to the lifeless tasteless but convenient wafer now made by 1 or 2 national companies displacing the hosts made lovingly by nuns, ours tastes good and represents the whole as described, spiritually centred and caring for the creation. We believe this is important. "You are indeed what you eat." Once the Church was aware of this universal knowledge.

In Canada the overall needs are support for small farm development, which by its nature involves quality and quantity in the production systems and social conditions. We also need related research and development…to include on farm research-site specific, where the farmer provides the system and the scientists fine tune this system. The farmer provides cash in kind as his contribution and the Government or other sources, the rest.

It is after all for the public good, not just for the stockholders. Support could help matters to improve here and give hope for smaller farm revitalisation, both here and elsewhere.