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# Renewable energy and sustainable futures

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**Abstract**

The development of renewable energy technology is now widely seen as important if the world is to move towards a sustainable approach to energy generation. However, there are a range of obstacles facing the rapid development of these technologies: they are trying to establish themselves in an outdated institutional, market and industrial context.

This paper looks at some of the institutional and social obstacles to the development and deployment of renewables and at how they might be reduced. It also attempts to set the development of renewables in the wider context of sustainable development. © 2000 Elsevier Science Ltd. All rights reserved.

## 1. The potential of renewables

Currently, there is much enthusiasm for renewable energy systems, such as wind turbines and solar cells, which many see as the archetypal ‘sustainable technologies’, that is, technologies that can continue to be used in the future without irreparably or irreversibly damaging the eco-system. With concerns about Climate Change growing, the rapid development of renewable energy technologies looks increasingly important. However, these technologies face an uphill struggle in trying to become established. While the development of the technology itself is relatively straight forward, the social and institutional implementation problems are often much harder to resolve.

Renewable energy technologies rely on the use of natural energy resources such as solar radiation, the winds, waves and tides, which are continually replenished and will therefore not run out. In addition, the use of these renewable sources does not in general involve the production of pollutants or other environmentally damaging emissions. It seems likely, therefore, that, as the environmental costs of existing

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energy technology become more apparent, renewable energy technology will increasingly come to the fore. Energy conservation must also obviously play a major role: the adoption of more efficient energy use patterns and techniques can perhaps help us to reduce overall demand by at least 50% in most sectors of the economy, and much more in some sectors (e.g. in buildings). But we will still need to find new supplies of energy.

Fortunately, the renewable resource potential is large, and the economics of the conversion technologies are beginning to look reasonable. For example, wind power is now seen as competitive with conventional sources in some contexts, and its costs are continually falling. There are already around 9000 megawatts of wind powered generating capacity around the world, equivalent to around four nuclear plants. The USA led the way, but Europe has caught up, with Germany's major wind power programme overtaking the initial lead held by Denmark [1]. The UK, which has Europe's largest wind energy resource, is following suit, with more than 30 wind farms already in place and more planned [2].

Windpower is not the only option. For example, in addition to developing a very successful wind turbine export business, Japan has launched a major very visionary 'New Sunshine' sustainable energy programme, which will involve the expenditure of some 1.55 trillion Yen (around £10 bn) by 2030, with a strong emphasis on 'photovoltaic' solar cells. The USA and Europe also have major photovoltaic programmes. Interest in various types of biofuels is also increasing around the world and there is a range of other renewable options under development, including wave energy systems and devices for extracting energy from tidal currents [3].

However, the process development of the various renewable energy technologies has revealed a number of major institutional problems which may make a rapid transition to a sustainable energy future difficult.

## 2. The problems of transition

Part of the problem is that renewable energy technologies are trying to establish themselves in an institutional, market and industrial context based on the existing types of energy technology. In the past, the emphasis has been on the use of large scale concentrated forms of energy, managed by large scale centralised agencies. By contrast, many renewable sources are diffuse and the technologies are smaller scale. The current financial, organisational and institutional environment is not very well suited to their acceptance: there is, arguably, something of a mis-match between the new technology and the existing support infrastructure. This has been particularly clear in the UK, where, at least initially, wind projects found it difficult to get finance, given the high rates of return and short pay back periods expected by private sector investors, and the risks they feel that these novel technologies involve.

However, in some cases the technology and the infrastructure are better matched, and this may provide an indication of how progress can be made in future. For example, wind power has been very successful when it was developed and deployed on a small, local, scale, as in Denmark. In the USA and the UK the emphasis was initially, in the early 1980's, on large megawatt sized wind turbines, developed with central government support on a high tech 'top down' basis by large aerospace companies. However these megawatt machines turned out not to be what the newly emerging wind power generation industry wanted — they were too large and complex.

By contrast, in Denmark, a more incremental 'bottom up' process occurred, with much smaller devices being developed by local agricultural engineers on almost a craft basis. The wind turbines they produced were gradually scaled up to around 300 kW and they turned out to be world beaters, selling in large numbers around the world. This export success was launched from a strong domestic market: around 70% of the 3000 or so of the wind turbines installed in Denmark are locally owned by Co-operative Guilds [1].

Local ownership and small scale development has meant that, in a country where banks were used to investing in local projects, funding was relatively easily obtained, Local ownership also meant that, so far, there has been very little public opposition to the siting of wind farms in the Danish countryside: as the Danes say "your own pigs don't smell". By contrast in the UK, although the opinion polls show that wind power is generally favoured, there has been some local objection to some of the wind farm schemes developed, as it were, by absentee owners [4].

Public reactions to local impacts could thus become a constraint on the development of renewable energy options like wind farms in the UK. Indeed, the scale of opposition seems to have been increasing, with the majority of wind project applications now being turned down at local Planning Inquiries. So far, despite having Europe's best wind energy potential, the UK has only managed to install around 320 MW of wind generation capacity, and progress has slowed dramatically in recent years. For example, before March 1997, 67% of inquiry decisions were in favour of the wind projects, whereas since then only 22% of applications have been successful.

Local opposition seems not to have been a significant problem in Germany, which has seen a very dramatic expansion of windpower deployment in the 1990's, with around 2500 MW of windturbine capacity in place by the end of 1998. Once again, local ownership, by farmers and other private individuals as opposed to large scale developers, seems to have played a major role in winning acceptance of this new technology, and this even seems also have been the case when the scale of the machines increased. Whereas, initially, the windturbines were typically of around 300 kW, now they are moving up scale to 750 kW and above, with 1 MW machines coming into service.

The advent of lower noise machines may have helped, but, in terms of local responses, physical size seems to matter less than ownership, at least once people have become familiar with the technology. Even so, these are still relatively small scale, local projects, compared with coal or nuclear power plants, which are typically of 1000 MW or more.

Interestingly, another major renewable energy source, fast growing energy crops like willow or poplar trees, also looks as if it will be best developed at the relatively small scale local level. Moreover, at this scale, it seems unlikely to lead to significant public concern, especially if use can be made of set aside land or other marginal land areas. This renewable energy source seems likely to fit in well with existing rural social patterns and agricultural economic practices. For example banks are used to providing loans to farmers, and the technical infrastructure for growing and harvesting crops already exists on farms.

This discussion highlights a general point which has emerged from current theorising on innovation: the successful deployment of new technology requires the existence, or the development, of suitable social and institutional contexts — a technical infrastructure, suitable financial networks, a skill base, along with the appropriate pattern of social acceptance [5].

## 3. Social impacts

The ‘social infrastructure’ side is perhaps the most complex. In principle, new technologies like renewable energy technologies, should be generally welcomed on environmental grounds. There may be some local impacts (such as visual intrusion with windturbines), but these are usually small compared with the large scale global impacts associated with conventional energy technologies. In general, renewable energy technologies, like wind turbines, have the advantage that ‘what you see is what you get’. They are functionally transparent, i.e. their purpose and operation is usually clear from their appearance, and there are no hidden or longer term environmental problems.

Nevertheless, there will be some environmental and social impacts. The widespread use of renewable sources could involve some changes in land use and landscapes, and could also lead to a shift to a more decentralised approach to energy generation, based increasingly on meeting local needs from local renewable sources. There would still be a need for grid networks to balance out local power availability and local demand around the country. However, using power from local sources directly has economic and technical advantages, since it can avoid the large power losses associated with distribution over long distances. This shift to relying on what power engineers call ‘embedded’ generation’, could in turn have social and economic implications. For example, the availability of renewable resources could influence the pattern of industrial location.

Although it has not involved the use of a renewable resource, a degree of decentralisation of generation has in fact already taken place in the UK as a consequence of the so-called ‘dash for gas’. This followed the break up/liberalisation of the traditional electricity market system in 1990, and was based on the use of medium scaled combined cycled gas turbines (CCGT), which have begun to replace the older and much larger coal fired plants. The drivers for this type of change were partly economic (natural gas is cheaper than coal) partly technological (CCGT plants have high conversion efficiencies) and partly institutional (privatisation and liberalisation). But it also had environmental implications, since the combustion of natural gas produces less carbon dioxide than the combustion of coal.

With environmental concerns increasing, it could be that the dash for gas and the shift to smaller scale generation will open up the way for a more general decentralisation of the power system, based on the use of local renewable sources. It could be that increasing use will be made of solar photovoltaic cells on buildings and co-generation of heat and power using biomass from local sources fed to Combined Heat and Power plants, with the grid network acting as a balancing back up [6].

Some observers argue that there is a fundamental change occurring in the overall system of energy production (see Table 1). In the past, the emphasis was on large scale generation systems, using non-renewable fossil or fissile fuel, managed by large centralised institutions, who often had a monopoly of the market. By contrast, the newly emerging pattern is based on smaller scale generation systems operated on a more decentralised base in a liberalised market, using renewable energy sources. Some see the emergence of this new pattern of energy generation as part of a wider shift in what innovation theorists call the 'techno–economic' framework or paradigm — a basic change in the dominant pattern of technical and organisational arrangements. In the new 'green' techno–economic paradigm a new strategic technological outlook develops from and interacts with the newly emerging environmental value system, but also requires, and is conditional on, changes in institutional and social infrastructure [6].

## 4. Changing paradigms

A key requirement for a shift to a new paradigm is the exhaustion of the previous one. In other words, there is no choice but to change. In the energy field, the growing concern over the Global environmental impacts of existing forms of energy generation and use would seem to provide a clear impetus for changes in approach: it is now widely felt that Climate Change will have major impacts in the world with the cost of limiting it (by energy conservation and by switching over to non-fossil fuels) being far less than the costs that will be imposed if nothing is done [7].

Nuclear power has sometimes been seen as the next major energy technology, and certainly it could help reduce carbon emissions. However, given its costs and risks, and wide scale public opposition, it seems an increasingly unlikely candidate for making a significant contribution. Even nuclear optimists estimate that at best it might be contributing around 7% of world energy by 2000 [8] and, at least in the

Table 1
A changing energy paradigm?

| | Conventional Paradigm | New Paradigm |
|---|---|---|
| Fuel Resource | Finite stocks | Renewable flows |
| Energy Type | Concentrated | Diffuse |
| Technology | Large Scale | Smaller Scale |
| Generation | Centralised | Decentralised |
| Environmental Impact | Large, global | Small, local |
| Market | Monopoly | Liberalised |

West, there seems little chance of expansion in the years ahead. Indeed, in most Western countries, nuclear power is in decline. By contrast, renewable energy technology is expanding rapidly, and, along with energy conservation, seems better attuned to the task of moving to an environmentally sustainable approach to energy supply and use [9].

However, there are strong forces defending the technological and institutional status quo, some of which, as is discussed below, have become manifest in strident denials from some fossil fuel interests that Climate Change is a significant problem. To some extent opposition of this sort may be inevitable. Even without vested interests in the status quo, given that opinions and perspectives differ in society, there is unlikely to be agreement as to when or if change is needed.

Even if it is not possible to get agreement on whether a particular techno–economic paradigm has had its day, some specific technological trajectories or technical options will turn out to be incorrect, and be recognised as so widely. Certainly the past is littered with examples of failed technologies, or technologies that have been abandoned. Such is the loyalty of product champions, that often there remain devotees of these abandoned or marginalised options, and in some cases their continued devotion may turn out to be correct (the Apple Mac computer may end up being an example, and some people might add the Betamax video format). It is interesting that some abandoned technologies make a come back e.g. when the technical capacity of designers, materials, control systems or whatever, has improved so as to make them more credible. Airships might be one example. Certainly some modern renewable energy technologies, such as water power and wind power, have their historical precedents.

What about the other side of the equation — letting go of failed options? If the technology in question has had powerful supporters in the past, then this can be difficult. There still tend to be vested interests in the innovation, and the institutional processes involved with supporting the innovation, resulting from past institutional investments (e.g. of money and time), and from personal commitments (e.g. in terms of professional reputations and careers). The institutional context can ‘lock in’ the technology in a way that makes it hard to phase out.

It is interesting to look at nuclear power in this context. Although there are still some areas of potential expansion, in Asia for example, Western nuclear programmes are being halted or wound down. R&D budgets have been falling, and it could be argued that, at least in its present form (predominantly, the US Light Water reactor design), nuclear fission is a failed technological approach. In a paper entitled ‘What Now?’, presented to a Conference on the ‘Next generation of Nuclear Technology’ at the Massachusetts Institute of Technology in 1993, Profs. M Cohn and L Lidsky, both members of MIT’s Department of Nuclear Engineering, concluded that:

> …for the time being at least, nuclear power has exhausted its privileged research funding position. Opportunity costs considerations require that competing technologies receive serious funding. Only if these options fail can a case be made for renewed flows of disparately large amounts of public funds to nuclear power [10].

They suggested that there could be a period of low activity, e.g. in terms of nuclear R&D, but felt that: “In some respects the interregnum, if there is to be a second nuclear era, may turn out to be a blessing in disguise for nuclear power. Many scholars have written about the problems of bureaucratic inertia in general and technological lock-in with respect to Light Water Reactors in particular. Even as the nuclear industry winds down, sunk costs in the commercial sector and interlocking subcultures in government bureaucracies and academia, inhibit innovation. A clean break offers the opportunity of a fresh start unburdened by intellectual and emotional bias.”

The paper argues against the more conventional view that it is vital to keep expertise alive, by suggesting that: “it may well be that we do not want to preserve our current knowledge” in that “it is not clear that current nuclear expertise will be relevant to nuclear projects 30–50 years from now”.

As can be seen, the authors are in effect prescribing a process of institutional disestablishment, with key elements in the support structure for the existing nuclear trajectory being dismantled in order to allow alternatives, whether nuclear or otherwise, to develop.

## 5. Social change

Some of the institutional constraints facing the development of renewable energy technology might be removed by a reduced commitment to older energy technologies like nuclear power. But, even assuming that these constraints, left over from the past, can be removed, there may also be newly emerging social and institutional obstacles associated with making a transition to a sustainable energy future. As has been indicated, renewable energy technology can be seen as part of a wider green techno–economic paradigm, in which technological and social patterns both interact and change. However, if the use of renewable energy technologies only makes sense in the context of significant social change e.g. in lifestyle and consumption patterns, then there could be opposition.

The key question is therefore, what scale of social change is likely to be needed to achieve an environmentally sustainable future? Energy generation and use is of course only one factor, but energy use is fundamental to most societies and, in terms of environmental impacts, it stands as a proxy for many other aspects of production and consumption.

From the purely ‘technical fix’ point of view, a move to energy sustainability would seem to be technically feasible without the need for significant social change. Energy wastage can be reduced dramatically in most sectors of use (domestic, industrial etc.) by the introduction of energy conservation techniques and the use of energy efficient devices, products and production systems, making it easier for renewables to supply the remaining energy requirements. Savings of at least 50% and perhaps up to 70% or more are seen as technically possible, and, as a study by Shell has suggested, in principle renewables might meet around 50% of global energy requirements by 2060 or so [11]. A study produced for Greenpeace estimated that renewables could supply 100% by the year 2100, given proper attention to energy conservation. Greenpeace claim that this can be achieved without there being a need to curtail economic growth, but the key factor would be the political will to make this transition [12].

At present, a fairly leisurely, incremental, approach to renewables and energy conservation seems to have been adopted around the world. However there are some notable exceptions. Some countries seem to have concluded that global environmental problems like global warming warrant a more radical approach.

For example Denmark and the Netherlands, have embarked on radical programmes of energy conservation, as well as the introduction of renewable energy technologies, backed up by a system of subsidies. These measures are designed to help meet some challenging targets for reducing emissions, for example, of carbon dioxide, a key ‘greenhouse’ gas. Denmark has already made a commitment to a 20% cut by 2005 and one pan-Scandinavian proposal was for up to a 95% reduction in carbon dioxide emissions by 2020. Given that the developed countries historically have benefited from, and continued to use most of, the worlds fossil fuel resources, 95% was seen as the sort of level of reduction that the developed Scandinavian countries should make in order to get the world total down by around 60% [13,14].

Would this sort of approach imply reduced levels of consumption for the advanced countries? Optimists like Amory Lovins argue that we can obtain at least a factor of four increase in resource use efficiency by the use of technical fixes of various types, and, in some cases, up to factors of ten improvements. So frugality is not needed in order to achieve sustainability [15].

However, not everyone agrees. For example, the Australian eco-design theorist Chris Ryan has argued that, although ‘technical fixes’ of various types in all the various sectors could go a long way to achieving significant reductions in energy and material usage, there could also be a need for overall patterns of consumption to change, with perhaps a move away from the emphasis on ‘quantity of material consumption’ and on to ‘quality of life’. Otherwise, consumption could still expand to overwhelm any savings from technical fixes [16].

Some environmentalists go further, claiming that there are inevitably going to be limits to growth on a finite planet, and that needs and expectations will have to be drastically limited by ecological constraints. For example, Trainer argues that technical fixes in the energy sector will not be enough and that there will be a need for radical social changes designed to reduce the impact of human activities on the ecosystem, including a shift to more decentralised economies, with local needs being met from local resources [17].

Within this changed social context, and taking a global perspective on board, the ‘deep green’ argument is that, not only should the people in the developed parts of the world be trying to ‘do more with less’, but they should also be expecting less, as a fairer share of what is available globally.

However, while there may be minority interest in ideas like Voluntary Simplicity and Downshifting, and while most people are happy with the general idea of energy conservation and materials recycling, for the moment the majority of people in the developed world would no doubt see more radical changes in lifestyle and consumption activities as a serious imposition, and would resist them. A shift away from consumerism, and any suggestion of lowered economic growth rates, would also no doubt be resisted by industrial interests.

## 6. Resistance to change

The problem of resistance to change becomes even clearer if we look at the international level. For example, progress on reaching international agreements concerning environmental controls on emissions has been slow. Vested interests in the status quo remain strong, and there is a conflict between the impetus towards global free market competition and environmental pressures for increased regulation. International bodies like the Intergovernmental Panel on Climate Change have suggested that there would be a need to move towards a 60% reduction in global carbon dioxide emissions if climate change was to be constrained. But, so far, no international agreements for anything like this have been achieved.

Following the 1992 UN Conference on Environment and Development in Rio, 160 or so countries agreed to try to get their carbon dioxide emissions back to 1990 levels by the year 2000. A follow up meeting on Climate Change held in Berlin in April 1995 found that only a handful of countries (the UK included) were likely to attain this target, while some others were still basically resisting the idea. Perhaps unsurprisingly, the Berlin conference was unable to get agreement on the target for the next phase, which the more concerned countries advocated, should involve a 20% reduction by 2005 [18].

Similarly there were major problems at the subsequent UN Climate Change Conference in Kyoto in December 1997, with US industrial interests in effect blocking significant progress. As a compromise, a global average reduction of around 5% was agreed, with the target dates set as 2008–2012. The most recent UN Climate Change gathering, held in Buenos Aires in November 1998, was convened to discuss mechanisms for meeting this target. Amongst these mechanisms was the idea of emission permit trading, that is, creating a market incentive for reducing emission. However, with opposition to the Kyoto agreement still strong in the USA and some other countries, in the event, the conference postponed discussion of emission trading and many of the other key issues for two years.

A similar lack of vision seems to exist amongst many of the international investment and funding agencies. For example, agencies like the World Bank are still investing much more on projects which will increase carbon emissions than on projects that will reduce emissions and the GATT global free trade arrangements overseen by the World Trade Organisation pay scant regard to environmental concerns. However, there are some signs of change. For example, the World Bank is supporting some ambitious solar energy projects in developing countries and, with pressure from environmental groups mounting, international agencies generally are waking up to the need to support sustainable development by technology transfer mechanisms focused on cleaner, greener technology [19].

## 7. Signs of progress?

Clearly, there is still some way to go before the global community will be able to respond effectively to the serious global environmental challenges that many feel lie ahead, but there are some signs of progress in the development of renewables.

Direct state investment in new technology development is out of fashion at present, at least in the West, but the market mechanism may help, in that renewable energy technology may become attractive purely on economic grounds. However, this process is likely to be slow, unless the environmental advantages of renewable energy use are factored into the economic assessment. It will remain cheaper in the short term to burn fossil fuels like gas since the environmental costs of using these fuels are not reflected in the price of the power produced. So, for the moment, most renewables are seen as expensive.

In the absence of economic mechanisms for taking these environmental costs into account, if a more rapid pace of renewable energy deployment is considered necessary, then there will be a need for some form of state intervention to stimulate and set the context for the market. As was noted earlier, Denmark has led the way with an innovatory approach to the development of renewables at the local level, and several European governments (including the UK) have set up cross subsidy schemes whereby consumers in effect subsidise the deployment of 'near market' renewable projects by private sector interests on an interim basis, helping them to become commercially established subsequently on an independent basis.

More recently, from 1998 onwards, following the liberalisation/deregulation of electricity markets in the USA, UK and elsewhere, some companies have been offering consumers an opportunity to contract directly for 'green power'. Initially, most of these schemes have involved a premium price for renewable sources, and have so far only tended to appeal to a minority of environmentally motivated consumers. However, as the technology and the market develops, prices should fall, thus creating the conditions for the more rapid expansion of the market for green power [20].

Even so, most companies are still worried about the costs of shifting to more sustainable approaches and believe that economic growth and competitiveness could be affected. The alternative view is that, since the worlds environmental problems will not go away, and pressures to clean up are likely to increase, companies and countries that invest now in 'clean green technology', including renewable energy technology, will be better placed competitively in the future [21].

On this view, the move to a more sustainable energy future is inevitable, and if there is to be growth, this is one area where it will occur. In this context, it is interesting that BP and Shell have both recently made commitments to strengthening their support for solar photovoltaics.

Adopting the longer term clean/green technology approach, the Business Council for Sustainable Development, and its successor organisations, have argued that industrialists are increasingly accepting the challenge of developing sustainable approaches to industrial activities generally [22] and this line of argument seems to be strengthening, with environmentalists claiming that there are many opportunities for environmental and economic 'win–win' solutions [23].

As was clear from the debates in the run up to the Kyoto Climate Change conference, not everyone is convinced that the adoption on the green technology approach can be achieved without serious dislocations and costs, and the level of industrial concern over environmental issues varies around the world. But, interestingly, a poll at the 1997 Confederation of British Industry (CBI) conference showed that 83 percent of the organisation's members supported the European Union's goal of a 15 percent reduction between 1990 and 2010 in emissions linked with global warming, while 62 percent of the CBI members believed that Europe should unilaterally pursue an ambitious target even if it was not endorsed by other industrialised nations.

Clearly then, some industrialists believe that regulation need not always undermine competition, presumably because it opened up opportunities for new lines of technological development. Thus, a spokesman from BP clearly saw its commitment to renewables in terms of market success when he commented: "It could well be that the first country to seriously address the issues of creating a market for renewables would become the central location for a major new international business sector — with all the positive consequences that carries in terms of economic activity and employment. There is great scope in all of this for government and business to work together to build the right conditions for renewables." [24].

## 8. Policies for the future

Some industrialists believe that global market competition will be sufficient to deliver a sustainable approach. However, not everyone is convinced that globalised market competition is compatible with environmental protection. Many environmentalists feel that, at the very least, there is a need for more international regulation (for example of emissions) to set the context of the global market. They also feel that there is a need for a major structural transition for the energy industries which would require major changes in market relations internationally.

The pessimists argue that, particularly given the huge imbalance of power and wealth around the world, nothing short of radical social change will suffice, and in their more gloomy moments, suggest that this will be hard to achieve without major changes in politics and values [25]. The optimists argue that technological adjustments, like the use of renewable energy technology and energy conservation techniques, will be sufficient, or more subtly, that a shift to the use of such systems will involve and require social and institutional changes that will make sustainability a possibility.

The debate on what might be needed to achieve a sustainable future will obviously continue. However, although they have different expectations of what it can be expected to achieve, both the optimists and pessimists see a role for renewable energy technology. So how should it be promoted?

There is a need for new forms of interim financial and institutional support, to help renewable energy technologies develop and get established, and to create the necessary new infrastructure. As has been noted, some relevant financial support structures already exist around the world to help take renewables from the end of the development phase to full scale commercial deployment, such as the UK's Non Fossil Fuel Obligation. In addition, as we have seen, new markets are also opening up for green power. These embryo markets need to be supported. So does Research and Development on new renewables — to ensure that new ideas feed into the expanding range of options.

Those who object to programmes of this sort often do so because they see them as involving unwarranted subsidies. The counter argument is that most of the existing energy technologies have already benefited form very large subsidies — and some still do. A shift to a level playing field seems not unreasonable. But beyond that, it can be argued that renewables should be given a positive stimulus, to reflect the fact that they have significant environmental advantages over the conventional technologies. This could of course be achieved if the price paid for energy reflected the full environmental costs of its production: then renewables would be strongly favoured. In the absence of energy or carbon taxes, emission trading systems, coupled with tight overall emission controls, may also help to provide some positive stimulus.

National and international government initiatives are needed in order to create and sustain programmes of this sort, but much of the dynamism can come from the market itself, if it is properly structured. What governments can perhaps best do is to focus on the problems of social acceptance and the practical deployment, in terms of planning law, of the technologies. The fact that, even given careful siting and design, there may be some local environmental disruption, must be set clearly against the much larger global benefits from the deployment of renewables. No one wants to accept local environmental intrusion without due cause, so a process of social negotiation must be developed to generate a consensus on what is acceptable and what is not — set in the overall context of global sustainable development [26]. Without that consensus, it could be that the main obstacle to the deployment of sustainable technology will be "Not in My Back Yard" styled local resistance.

## 9. Conclusion

Renewable energy technology offers a partial and timely solution to many of our environmental problems, but the fleshing out of the full green techno–economic paradigm will involve a shift away from economic short termism and a positive, global, vision of the longer term future. It will involve a range of adjustments to the way we use, and think about, technology. As the Australian environmentalist Sharon Beder has put it:

> So long as sustainable development is restricted to minimal low-cost adjustments that do not require value changes, institutional changes or any sort of radical cultural adjustment, the environment will continue to be degraded [27].

On this view, the development of sustainable technologies is only part of the process of moving towards a sustainable future: that will also require social and institutional changes, including, presumably, new attitudes and expectations concerning consumption and affluence. It will also require us to re-think our attitudes to the interaction between technology and the environment.

This is particularly clear in the case of energy technology. In the past we have been able to hide much of it away and, apart some obvious local problems, most people have only become aware of its hidden costs as these have impacted on the global environment. Rather than relying on high intensity stored natural energy (fossil or nuclear), renewable energy technologies make use of diffuse natural processes in the environment — in real time. These new energy technologies are somewhat more visible, as are their environmental costs.

If these costs are deemed to be unacceptable, and if we also want to avoid the global environmental problems associated with the existing energy technologies, then radical reduction in energy use and economic activity of the current type does indeed seem to be the only option. That may be to overstate the case, in that we can in fact make huge savings in energy use which may help us to reduce the need for new energy supply technologies of whatever sort. However, if the Climate Change problem is as significant as some think, then we will need all the renewables and all the energy efficiency savings that we can obtain.

So a sustainable energy future is clearly not an easy option. By 2050 we might hope to be obtaining around half of the worlds energy from renewable sources and to have held growth in energy use down to some extent. The longer term prospects clearly depend on the rate of growth. Taken together, if fully developed, global renewable sources might ultimately supply perhaps 200,000 TWh pa — twice the level of primary energy currently used [28]. So there is room to grow, but also an absolute limit to how much growth can be accommodated by renewables. Sooner or later, unless we come up with a new source of power, we will have to face the difficult issue of how to limit our material expectations.

The prospects for new energy technologies which might lift this constraint are uncertain. Nuclear Fusion seems as far off as ever, and has its own range of safety and environmental problems [29]. ‘Zero point’ or ‘free space’ energy enthusiasts would have us believe that they have the answer [30]. But for the moment the best bet would seem to be to develop renewable energy technologies to make use of the energy delivered to us free from the fusion reactor we already have — the sun — which can provide sufficient energy to meet our needs for the immediate future. However, that doesn’t mean that we should postpone discussing exactly what it is we should be doing with this energy.

## References


[1] Gipe P. Wind power comes of age. London: Wiley, 1995.

[2] Department of Trade and Industry. New and renewable energy: prospects for the 21st century. London: HMSO 1999.

[3] Boyle G, editor. Renewable energy: power for a sustainable future. Oxford: Oxford University Press/Open University Press, 1996.

[4] Elliott D. Public reactions to wind farms: the dynamics of opinion formation. Energy and Environ 1994;5(4):343–62.

[5] Freeman C. The economics of hope. London: Pinter, 1992.
[6] Patterson W. Transforming electricity. London: Earthscan, 1999.
[7] Mays R. Climate change. Paper by the UK Governments Chief Scientific Adviser, Department of Trade and Industry, September 1997.
[8] Maisseu A, Delanoe A. Energy in Europe and in the world, 1995. Int J Global Energy Issues 1995;8(1/3):6–30.
[9] Elliott D, Clarke A. Developing criteria for sustainable energy technology. Int J Global Energy Issues 1997;9(4/5):264–327.
[10] Cohn M, Lidsky L. “What Now?”. Paper to Conference on the Next generation of Nuclear Technology at the Massachusetts Institute of Technology, Cambridge, October 1993.
[11] Shell. The evolution of the world’s energy system 1860–2060. London: Shell International, 1995.
[12] Greenpeace. Towards a fossil free energy future. London: Stockholm Institute report for Greenpeace International, 1993.
[13] Meyer N, Benestad O, Emborg L, Selvig E. Sustainable energy scenario’s for the Scandinavian countries. Renewable Energy 1993;3(213):27–136.
[14] Norgard J, Christensen B. Towards sustainable energy welfare. Persp in Energy 1992-1993 1994;2:313–32.
[15] Von Weizsacker E, Lovins A, Hunter L. Lovins factor four. London: Earthscan, 1997.
[16] Ryan, C. The practicalities of eco-design. In: Harrison M., editor. Eco-design in the Telecommunications Industry. London: RSA Environmental Workshop 3–4 March; 1994.
[17] Trainer T. The conserver society: alternatives for sustainability. London: Zed Press, 1995.
[18] Grubb M, Anderson D. The emerging international regime for climate change. London: Royal Institute of International Affairs, 1995.
[19] French H. Investing in the future: harnessing private capital flows for environmentally sustainable development. Worldwatch Paper 139. Washington DC: Worldwatch Institute, February 1998.
[20] Elliott D. Green Power and the liberalisation of the UK electricity market. Int J Ambient Energy 1999;20(1):3–13.
[21] Wallace D. Sustainable industrialisation. London: Royal Institute of International Affairs, 1996.
[22] Schmidheiny S. Changing course: global business perspective on development and the Environment. Cambridge: MIT Press, 1992.
[23] Elliott D. Sustainable innovation. Paper to the TASM/UWE Conference. Constructing Tomorrow, Bristol, September 1998, proceedings published June 1999.
[24] Chase R. Deputy Group Chief Executive Officer and Chief Executive, BP Oil. Paper to the Royal Institute of International Affairs, London, quoted in Renew 118, March–April, 1999.
[25] Goldsmith E. The way. 2nd ed. London: Themis Books, 1996.
[26] Elliott D. Energy, society and environment: technology for a sustainable future. London: Routledge, 1997.
[27] Beder S. The role of technology in sustainable development. Tech and Soc 1994;2(4):14–9.
[28] Grob G. Transition to the sustainable energy age. European directory of renewable energy. London: James and James, 1994.
[29] Parliamentary Office of Science and Technology, Nuclear Fusion Update, POST Note 120, London, 1999.
[30] The US Journal Infinite Energy. For a critique see Infinite Energy Renew 109 Sept–Oct, 1997.

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