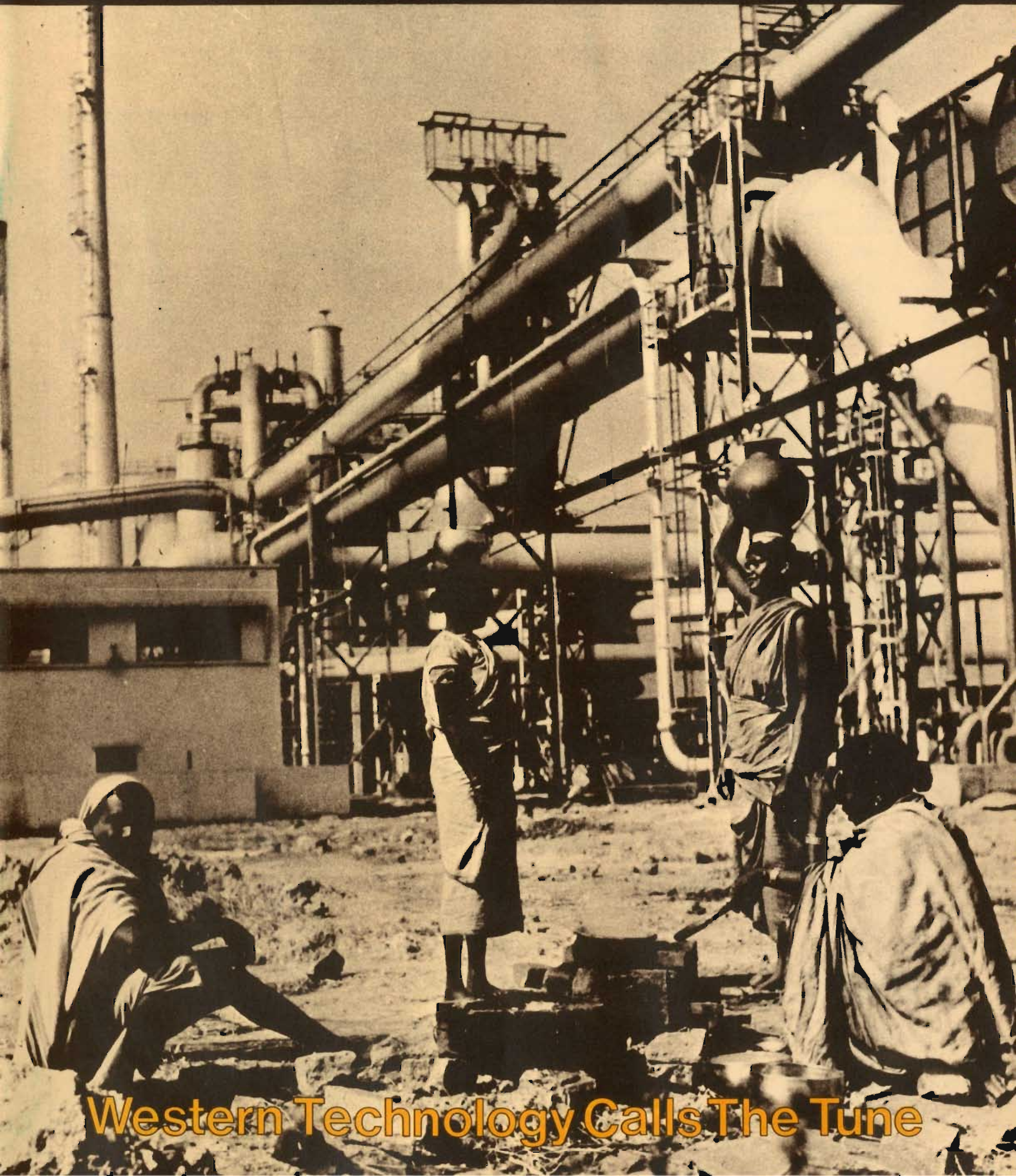
The Ecologist

Journal of the Post Industrial Age Vol. 12 No. 2 1982 £2



Western Technology Calls The Tune

◀ including:

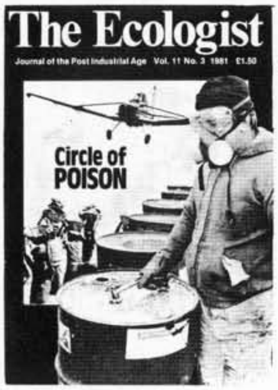
Nicholas Hildyard, **The Riots: Reaping the Bitter Harvest.**

R. Franke and B. Chasin, **Peasants, Peanuts, Profits and Pastoralists.**

Hartmut Vogtmann, **The Quality of Plant Foods.**

Pierre-Marie Brunetti, **A New Look at Contraception.**

Edward Goldsmith, **Thermodynamics or Ecodynamics?**



◀ including:

B. Castleman and M. Vera Vera, **The Selling of Asbestos.**

D. Weir and M. Schapiro, **The Poisoned Circle.**

Brian Morris, **Changing Conceptions of Nature.**

J. Harvey, R. Piccioni and D. Pisello, **Cleaning up of Three Mile Island: How many will die?**

including:

Nicholas Hildyard, **Forestry for the Future.**

Alan Grainger, **Reforesting Britain: A Special Report.**

Peter Bunyard, **Windscale: Who needs it?**

Ross Hume Hall, **Nutrition and Cancer.**

▶

including:

Nicholas Hildyard, **Can We Trust Scientists.**

Robert Sinsheimer, **The Presumptions of Science.**

Donald H. Hughes, **Early Greek and Roman Environmentalists.**

Nigel Pollard, **The Gezira Scheme: A Study in Failure.**

Brian Martin, **The Scientific Straitjacket.**

Alan Grainger, **The Battle of Terania Creek.**

▶

◀ including:

Edward Goldsmith, **Preparing for the Collapse.**

Robert Waller, **Scientific Materialism.**

Vince Taylor, **Subjectivity and Science.**

Edward Goldsmith, **The Ecology of Health,**

as well as special birthday contributions from Robert Allen, Michael Allaby, Andrew MacKillop, Nicholas Hildyard, Peter Bunyard, Jimoh Omo-Fadaka, Lawrence Hills, Sam Love and Nicholas Gould.

◀ including:

Colin Sweet, **The Weapons Connection.**

Peter Bunyard, **Nuclear Power, the Grand Illusion.**

N. Hildyard and P. Bunyard, **The Chink in the Nuclear Armour.**

Edward Goldsmith, **Ethnocracy: The Lesson from Africa.**

The Ecologist

Journal of the Post Industrial Age

Published by: Ecosystems Ltd., Edward Goldsmith

Editors: Edward Goldsmith, Nicholas Hildyard, Peter Bunyard. Managing Editor: Maria Parsons.
Associate Editors: Robert Prescott-Allen, Brian Johnson, Bernard Gilbert, Jimo Omo-Fadaka, Andrew Mackillop, Robert Waller, Lawrence Hills, John Papworth, Nicholas Gould, Raymond Dasmann, Richard Wilson, John Milton (USA), Henryk Skolimowski (USA), Manfred Siebker, Sigmund Kvaloy (Norway), Wouter Van Dieren (Holland).

Editorial Department: Whitehay, Withiel, Bodmin, Cornwall, UK. Tel: Lanivet (020883) 237.

Annual Subscriptions:

Ordinary Rate: £11.00 (US $28,00) (Students £10.00)
Institutional Rate (excluding schools): £16.00 (US $36.00)
Airmails Rates: £5.00 (US $10.00) extra
Special Rates for Members of the Ecology Party: £10.00

Subscriptions are payable to The Ecologist and sent to:
The Ecologist, Subscription Department, Worthyvále Manor Farm, Camelford, Cornwall PL32 9TT. UK. Tel: (0840) 212711

The Ecologist Bankers: National Westminster Bank Ltd.,
26 Molesworth Street,
Wadebridge, Cornwall. UK.

Advertisements:

Display Rates:	Full page (261x185mm) £150. Half page (131x185mm) £80 Third page (131x121mm or 261x58mm) £50 Quarter page (131x121mm) £40 Sixth page (131x58mm) £30
Inserts:	Up to 261x185mm and not more than 10g £12 per thousand.
Enquiries to:	The Ecologist, Advertisement Department, Worthyvale Manor Farm, Camelford, Cornwall PL32 9TT. UK. Tel: (0840) 212711.

Contributions:

The editor welcomes contributions, which should be typed, double spaced, on one side of the paper only, and with generous margins. Contributions should be accompanied by black and white photographs, line drawings, and tables where appropriate.

While every care is taken with manuscripts submitted for publication, the Editors cannot guarantee to return those not accepted. Articles published in the Ecologist do not necessarily express the views of the Editors.

The Ecologist's International Serial Number is ISSN 0261-3131.

Printed by: Penwell Ltd., Parkwood, Dupath, Callington, Cornwall. UK.

The
Ecologist

Vol. 12 No. 2 March/April 1982

Editorial

Feature Articles

Cover photograph: Camera Press, Terry Fincher
Cover layout: Steve Womersley

An Environment Programme — but for whom and what?

In mid May, the United Nations Environment Programme — UNEP — is holding a meeting in Nairobi to celebrate ten years of existence and to consider how best to deploy itself in the future. To mark the occasion, UNEP has produced a document, *The Environment in 1982: Retrospect and Prospect*, which aims to give a realistic picture of the past ten years as seen from an evironmental perspective and to indicate outstanding areas of concern.

Without question, UNEP has been party to some impressive achievements. In 1975 and 1976 for example it got the Mediterranean countries to agree on a convention, a series of protocols, as well as on an action programme to control pollution of the Mediterranean Sea. In May 1980, the same countries agreed on a third protocol to control land-based sources of pollution, and yet a fourth on endangered species and habitats is in the process of going through. In another venture, UNEP has joined with the World Health Organisation to establish an International Register of Potentially Toxic Chemicals, the aim of which is to provide governments with guidelines on conditions under which those chemicals may be used. Keeping a weather eye on the global environment has been one of the cornerstones of UNEP's activities, and through its 'Earthwatch Programme' UNEP has set up GEMS — a Global Environmental Monitoring System, the purpose being to collect data on potentially detrimental changes to the biosphere brought about by man's activities.

Yet, as UNEP candidly admits, the last ten years have not seen a striking improvement in the earth's environment. On the contrary, environmental degradation continues apace and threatens the existence of Man, as well as of a host of other organisms. Nor is it straightforward pollution that is necessarily doing the wiping out; indeed UNEP refers to an estimate that in 1980 alone as much as 20 million hectares of once productive land deteriorated 'to a level at which it yielded zero or negative net returns.' It is hardly surprising to see the same UNEP document informing us that as many as one thousand million people — nearly one quarter of the world's population — may die of starvation before the end of the century.

What in effect can UNEP do about such horrifying prospects? At the conclusion of its report on the environment, UNEP lists a series of 'trends' which if continued will lead to widespread enviromental deterioration and possibly to irreversible changes. UNEP thus refers to acid rains caused by the burning of fossil fuels, accumulation of carbon dioxide in the atmosphere, potential depletion of the ozone layer, the destruction of fisheries through pollution and excessive exploitation, the loss of tropical rain forests, the spread of deserts and the dislocating effect on people of floods and droughts. The growth of cities too, comes in for a mention, and UNEP reminds us that by the year 2000 developing countries between them may have as many as 60 cities with more than 4 million inhabitants each compared with one such city — Buenos Aires — in 1950. Since some of those expanding cities may, like Mexico City, attain more than 20 million inhabitants, the strain on the local environment is bound to be immense. What does UNEP suggest? Ways to halt the flow of migrants through incentives for people to stay in their villages? Not a bit of it: the priority is to establish 'appropriate pollution control measures' and to expand 'technical training programmes' presumably for the operation of those very measures.

Indeed, while it is hard to fault UNEP on its analysis of trends, when it comes to proposed actions serious doubts must surely remain as to UNEP's effectiveness. In practically every instance, UNEP's priority, it seems, is for more research, better assessment, expanded environmental monitoring. In effect, the gathering of information is a way to avoid real action and confrontation; it is a technique for procrastination, a fiddling while Rome burns. Thus UNEP tells us that we need 'continued research on flood and drought predictions'. We must surely disagree, since we already know through documentations, going back to ancient times, that the way to avoid floods is to refrain from deforesting the areas that surround rivers and their headwaters. As for droughts, they too can be caused by altering regional climates through deforestation as well as by damaging soil structure so that its water-absorbing capacity is reduced even in the absence of any reduction in precipitation.

UNEP also tells us that we need 'an expansion of current research on long-range transport of sulphur-dioxide.' Again we must disagree. Costly studies, like that of OECD, have already been carried out which shows the connection between sulphur dioxide emissions and acid rains which may fall hundreds of miles away. As for carbon dioxide and the greenhouse effect on the earth's climate, we need to do more than wait for UNEP and other organisations to tell us that an irreversible change has been set in motion. We need to make sure through positive action that the amounts of greenhouse type gases reaching the atmosphere are significantly reduced, and to achieve that in today's terms means burning less fossil fuels.

Having ascertained through research and monitoring the mechanisms of environmental change beyond all reasonable doubt, it is UNEP's intention to persuade governments, industries and public bodies to accept technological and institutional controls. Without question, many of the larger industries in industrialised countries have made considerable advances over the past decade to control discharges and emissions and even to reduce their energy requirements. Indeed, pollution control in certain industries, the pulp and paper industry for example, has proved to be well worthwhile and cost-effective. Yet the experiences of individual industries, are insufficient in themselves; the problem is that neither technological nor institutional controls have succeeded in slowing down, let along reversing any of UNEP's list of major trends.

Not that UNEP is naive. It is wholly aware that the establishment of rigorous controls must lead to added administrative technical cost, and hence to the temptation, particularly with struggling industries, to find illegal ways out; to get a Mafia to do the dumping of hazardous waste, or to find a country prepared to write off its heritage for the sake of business.

As for certain hazardous substances, the pesticides, they are literally manufactured for disposal, and in effect agro-industry has obtained such a hold on agricultural and horticultural production that the notion of any real control over their manufacture and use is simply ludicrous. Moreover the United Nations Food and Agricultural Organisation is among the largest promoters of the use of pesticides in the world and has even engineered such a crackpot and environmentally dangerous scheme as the spraying of DDT across the entire strip of savannah in Africa, to get rid of the Tsetse fly so that farmers can get rich on beef-raising. In reality the Tsetse fly is the last bastion against the total environmental rape of Africa.

If UNEP is inadequate, it is hardly its fault since it came into existence at the end of the 1972 Stockholm Conference with little financial support and with limited powers. Moreover its income in real terms has been steadily eroded away through inflation and through countries backing away from their obligations. In addition, UNEP's creators wanted an environmental organisation which would faithfully reflect their attitudes. Thus the industrialised countries were keen to show that environmental issues were grossly exaggerated, and when they did exist that they had technical solutions. According to such countries, Britain included, hasty actions to counter pollution and other environmental degradation on the basis of inadequate data were likely to be counterproductive, leading to overpriced, non-competitive goods for little real environmental gain.

The developing countries too were quick to see themselves threatened by a flurry of environmental activity that could put up the price of goods and in certain instances, such as pesticides, limit their availability. Indeed Indira Gandhi herself made a heart-rending plea for the millions of destitute in the world, not least in her own India, claiming that it was not the pollution of plenty that was causing misery but the pollution of poverty. Consequently UNEP became party to the slogan 'development without destruction', the notion being that industrial development *per se* was not the root cause of environmental damage. As an extension of that notion UNEP now states that 'in developing countries particularly, economic growth is vitally important and remains a major force for improving the health and welfare of people', and that 'economic growth can often be managed not only to avoid environmental degradation but also, in many cases, to improve the environment.' UNEP suggests that the best remedy against bad development is to foster the use of environmental impact assessment and of cost-benefit analysis.

But the success story of a well-sited factory, equipped with the latest pollution-control technology and buffered from population centres by a green belt says nothing about the real damage done to the environment through the breakdown of traditional values and culture and their replacement with the need for the artefacts of the consumer society. The 'clean' factory is the other side of the same coin, as the unchecked flow of humanity to the shanty towns, to the wholesale cutting down of the tropical rain forests and to potential climate change. Indeed UNEP calls for a reduction in the consumption of fossil fuels. Yet what alternative to fossil fuels is there for powering a developing world industrial system? Nuclear power we know to be a red herring and the energy renewables inadequate to the task of giving all humanity the kind of lifestyle practised in Western industrialised countries. Without actually bodly stating it, UNEP is calling upon governments to forego economic growth for environmental reasons, and that we know they will not willingly do.

Of course in its struggles for existence, UNEP can hardly bite the hand that feeds it. Yet if it wants a real function over and above that of offering palliatives UNEP must have the courage to tell the truth — to tell industrialised and developing countries alike that it is development that is the scourge of mankind and destroyer of worlds.

This editorial is an abbreviated version of Edward Goldsmith's critique of the UNEP document, ref: UNEP/GC(SSC)/2. Edward Goldsmith has been invited, as a 'resource person' to attend the UNEP meeting in Nairobi from 3-18 May, to mark the tenth anniversary of the 1972 Stockholm Conference on the Human Environment.

Appropriate Technology for the Third World; Why the Will is lacking

by Dr David Burch
School of Science, Griffith University, Brisbane, Australia.

Despite appropriate technology being technically and economically feasible it has patently failed to take root. The reasons for that failure are primarily socio-political.

The the literature on appropriate technology, the major emphasis so far has been concerned with questions relating to engineering—is it technically viable?; economics—is it economically efficient?; or social structure—is it socially desirable? However, these approaches have largely ignored, or assumed to be non-problematic, the political dimension which perhaps raises the most important question of all—is it politically possible?

For many years past, academics, politicians and administrators have looked to science and technology to solve the pressing problems of the underdeveloped countries. During the late 1950s and early 1960s there was a widespread sense of optimism which suggested that western science and technology would play a major role in eliminating poverty, hunger and disease in the underdeveloped world. It was argued that the advanced science and technology of the industrialised nations offered unique opportunities for the poorer countries of the world; they would not have to go through the process of 're-inventing the wheel', and since the costs of developing new technologies had already been recouped by the industrialised world, poor countries could obtain access to knowledge and advanced technology relatively cheaply[1]. There was an abundance of available technologies and, in the words of Lord Blackett, poor countries would be in the position of drawing up a 'shopping list' of what to buy in 'the world's well-stocked supermarket, for production goods and processes'[2]. In this approach, technology was to supply the 'missing link' in development. It was assumed that the predominance of 'primitive' and inefficient techniques of production was the prime cause of low growth, and the solution of this lay in importing foreign technologies which would increase labour productivity and growth rates, and hence speed up the process of 'development'.

The Cost of Development

With the end of the first United Nations Development Decade in 1970, however, a more sceptical and critical analysis of the role of western science and technology in the development process replaced the optimism which had earlier prevailed[3]. There were numerous reasons for this; at the most general level, the gap between the rich and the poor countries, measured in terms of income per capita, had continued to widen, sustaining the pattern which had long prevailed. Moreover, what little had been achieved by the underdeveloped countries had cost them dearly, especially in terms of debts accumulated under aid programmes[4]. In addition, numerous studies focused on the existence of large scale structural unemployment and underemployment in many Third World countries, which, in many instances, was closely related to the use of labour-displacing western-technology[5]. A further development, in part related to the question of unemployment, was the growing income inequalities within many underdeveloped countries[6].

To many observers, the prospects for the underdeveloped world seemed infinitely worse at the end of the first UN Development Decade than at the beginning. In analysing why this should be, many development theorists began a re-examination of fundamental concepts, and attention came to be focused on on a number of issues, two of which concern us here. The first revolves around the sectoral allocation of resources available for investment, while the second is concerned with the level of technology, in all sectors of the economy, that these resources were invested in.

As far as the sectoral allocation of resources was concerned, it was clear that local capital and external finance has been directed mainly towards industry and infrastructure, to the detriment of agriculture. In the case of official aid flows, for example, in the twenty-five years following the establishment of the World Bank, only $4 billion, out of a total of $25 billion disbursed as Bank aid, was devoted to agriculture. By 1973, the Bank's priority sectors for cumulative loans totalling $20 billion were transport ($6 billion), electric power ($5.7 billion), industry ($3.3 billion), with smaller sums going to agriculture, telecommunications, water supply, education, tourism, population control and urbanization in that order[7]. Given that the vast majority of the population of the underdeveloped world live in rural communities, and was dependent on agricultural production, it was argued that the concentration of resources on transport, power and industry constituted a serious misallocation of resources which could lead only to severe imbalances in the economic and social structure of the underdeveloped world.

Western Technology: the wrong Approach

The second area of concern revolved around the role of western science and technology in the underdeveloped world. It was argued that much of the western technology which had been transferred was 'inappropriate' in that it was generally capital-intensive. At its simplest, this meant that technologies designed for use in the industrialised world, where there existed a scarcity of labour relative to capital, were not appropriate to the factor endowments of the underdeveloped world where, generally speaking, there existed an abundance of labour and a shortage of capital. Western technology, developed to replace a relatively expensive factor of production (labour) with a relatively cheap factor (capital), resulted in unemployment or only a slow growth of employment when applied in the underdeveloped world, where labour was abundant and cheap, and capital scarce and costly[8].

The use of capital-intensive technologies not only led to increased unemployment but also widening disparities in income. The local ownership of capital-intensive western technologies was inevitably concentrated in the hands of the minority of wealthy investors who thereby received the major share of the benefits of growth that the technology made available. Even where capital-intensive technology resulted from foreign investment, with ownership located overseas, a small number of Third World groups were able to benefit disproportionately. For example, since by definition wages are a small part of the total costs of a capital-intensive operation, employers are generally very willing to concede pay increases, especially since the only alternative is to see expensive equipment lying idle. Thus, there have emerged well-paid urban workers in the Third World who have opened up a wide gap between themselves and the rural poor[9], a situation which reflects a general trend in the Third World for income inequalities to widen[10].

The increased use of western capital-intensive equipment had also created a situation of 'technological dependence'. Once displaced, indigenous technologies were often lost for good; skills were forgotten or not passed on, while links with those providing supporting inputs, techniques or raw materials were lost, leading to a dependence upon foreign technology. Such 'technological dependence' manifested itself in other ways as well, particularly in establishing the terms upon which underdeveloped countries gained access to advanced western technology. Far from being a good bargain cheaply purchased in the world's technological supermarket, western technologies often proved to be extremely costly. Under certain conditions, most notably when the transfer of technology resulted from private foreign investment, an underdeveloped country could pay dearly for technology from the West. Control over patent rights, licensing agreements or the use of brand names, or an agreement to supply 'necessary' inputs, all ensured a strong bargaining position to the technology supplier which resulted in a high price for these 'goods' and the extraction of large profits from the underdeveloped country[11]. This situation was partly a result of the widening gap between the industrialised and underdeveloped countries in the field of science and technology. It was calculated at the time that, excluding expenditures made by the centrally-planned economies (notably the Soviet Union and its satellites), the less-developed economies accounted for only two per cent of world expenditure for scientific research and development (R and D)[12]. Moreover, what little was spent within the underdeveloped countries was often 'marginal' to their development needs, being oriented mainly towards pure research problems delineated by the international scientific community, rather than applied research and development generated by internal needs and problems[13].

The extent of industrialised-country control over advanced technology in less-developed countries is indicated by the extent to which patents over industrial and other processes are increasingly controlled by non-nationals in the Third World. The situation in the case of Chile is quite clear:

Table 1: Ownerships of Patents Registered in Chile

Year	Owned by National	Owned by Non-nationals
1937	34.5	65.5
1947	20.0	80.0
1958	11.0	89.0
1967	5.5	94.5

Source: Cited in R. Muller, 'The Multinational Corporation and the Underdevelopment of the Third World', in C.K. Wilber, (ed.). *The Political Economy of Development and Underdevelopment,* Random House, New York 1973, p.127.

There is little reason to believe that the situation found in Chile is very different in other less-developed countries, where growing foreign control (mainly by the transnational corporation or TNC) of patents ensures the high price paid by the Third World for western technology, as mentioned earlier[14].

In summary, then, the problems of the underdeveloped world at the end of the first UN Development Decade in 1970 were to many observers, worse than they had even been. In this situation, it was argued that western technology, far from alleviating these problems, had exacerbated them. A re-appraisal of fundamental concepts went hand-in-hand with an analysis of development strategies and taken together, these led to the emergence of the concept of 'appropriate technology'.

The Implication of Appropriate Technology

The concept of appropriate technology has a number of inspirational roots which, as Jequier has observed [15], are to be found within both the industrialised and underdeveloped worlds and which combined to give a new emphasis in development studies. There emerged alternatives to received doctrine which defined development purely in terms of economic growth. New conceptions of development were gradually emerging, and if these disagreed on fundamental definitions, they could at least agree on the broad outlines of the strategy. This was based on rural development utilising, wherever possible, appropriate techniques of production. It was argued that such a strategy would reach the poorest groups in society and by meeting their 'basic needs' in housing, health, employment, education, etc., would significantly influence their social position. The use of appropriate technologies would create more jobs and reduce unemployment, thereby eliminating one of the most pressing causes of inequality. The development of small, decentralised production units would also create jobs where the demand existed, reducing the drift to the cities as well as eliminating the cost of transporting goods centrally produced in large urban factories to their point-of-sale or use. Low-cost appropriate technologies would be accessible to the many, so reducing the ability of the minority with the capital to invest in capital-intensive techniques to control the productive process and harvest the profits which followed from such control. Furthermore, a strategy based on the use of appropriate techniques would lessen the 'technological dependence' of the underdeveloped world on the industrialised nations. Simple, but efficient appropriate technologies could be produced within most underdeveloped countries, which would ultimately lead to a development process based on internal basic needs satisfied by locally-produced technologies, rather than production for the world market based on imported technologies[16].

From this description, the internal consequences of a strategy of appropriate technology for the Third World in general are clear. In broad terms, a picture can be painted of a country adopting a wide range of labour-intensive, small-scale technologies in many areas of agriculture and industry, producing goods for local consumption by the poorer groups in society who, having found productive work under such a labour-intensive strategy, now receive cash incomes to translate their needs into effective demands. Such a strategy implies greater equality within society, and an economic system oriented less towards the world economy, and more towards the national economy with hopefully, regional co-operation between neighbouring underdeveloped countries in an effort to generate greater trade between countries operating under similar conditions.

However, such a strategy would also have far-reaching consequences for the global economy, implying as it does a greater self-reliance in technology, which would inevitably reduce the demand (actual or anticipated) for technology from the industrialised countries, and a reduction of the direct and indirect costs associated with this demand. Unfortunately, no research that I am aware of has been directed towards analysing the adjustments in trade, and the associated costs and benefits, which would accompany such a shift in development strategy. There is no indication of the consequences should even only one Third World country adopt such a strategy, and certainly no global picture exists of the world-wide consequences should a large number of Third World countries follow that path of development. An attempt is made later in this paper to outline some general observations on this issue based on a case study of the energy sector, but for the moment it can only be suggested that there would be a reduction in imports of western technology or in the level of expected future demand. Either way, this could have serious repercussions for the industrialised economies, and especially for the transnational corporations (TNCs) which are responsible for the bulk of foreign investment made in the Third World. UNCTAD figures show the direct costs of technology transfers by TNCs to be some —1500 million in 1968, a figure which has been rising annually by 20 per cent[17]. To this must be added the indirect costs associated with payment for patents, licensing fees and so forth[18]. Clearly, a reduction in these costs, highly desirable for obvious reasons and highly likely if Third World countries adopted alternatives to western technology, would be very significant for the western interests involved. Among other things, reduced markets would mean fewer economies of scale to producers, with resulting increases in the costs of production of goods destined for western markets. This could lead to lower profits to producers, or alternatively an attempt to maintain profit levels by increasing prices of goods sold in western markets. The first could lead to reduced investment and a slowing down of economic activity, while the second could lead to increased inflationary pressures in the industrialised countries. And although such consequences would also have some ramifications for the Third World, as they do now, nevertheless it is possible to argue that these would be much reduced if the Third World was pursuing a policy of greater self-reliance in technology and other matters, vis-a-vis the industrialised countries.

However, there are strong grounds for doubting that the anticipated benefits of appropriate technology to the Third World will materialise under existing con-


The drift to the cities is a consequence of conventional development.

ditions. It can be argued that there are political, economic and social factors which inhibit the widespread introduction of appropriate technologies, or which only allow them to be introduced under conditions which distort the social goals of the appropriate technology movement. In short, under existing conditions, appropriate technology is likely to benefit only a minority within the Third World and, in the process, may create a new technological dependency upon the industrialised countries. The theoretical basis of this argument is discussed in the next section, and following on from that an attempt is made to give this empirical support through a case study of energy in the Third World. At the same time, it is hoped that this case study will indicate, albeit crudely, some of the implications for the global economy that would follow, should a strategy based upon alternative energy technologies be adopted by the Third World.

For analytical purposes, the theoretical section is discussed in two parts. The first analyses some of the internal factors within the Third World which impinge on the introduction of appropriate technology, while the second part discusses the role of external factors shaping the kind of technology made available to the Third World and the conditions under which such technology is transferred.

The Internal Dimension: Class Structure and Technological Choice

On the face of it, the concern of the appropriate technology movement to stimulate 'inequality-reducing' techniques has much to commend it: but a strategy for achieving social justice and greater equality in underdeveloped countries through the use of appropriate technologies comes up against a major contradiction, namely the way in which a prior distribution of income establishes a structure of demand and patterns of consumption which inevitably lead to the use of capital-intensive technologies[19].

The argument runs as follows. Income distribution in the underdeveloped world is, with a few exceptions, more heavily skewed in favour of the middle and upper class than it is in the industrialised world. These classes dominate consumer goods markets and establish a structure of demand for the same kinds of goods and services as consumers in the industrialised countries, e.g. cars, sophisticated kitchen equipment and consumer durables, luxury housing, fashion clothing, and so on. This demand may be met by importing these goods from the industrialised world, where foreign exchange resources permit this. In this case, the underdeveloped economy will remain locked into the world market system; much domestic production of cash crops or raw materials will be aimed at this market with the intention of earning the foreign exchange needed to maintain these patterns of consumption through imports. The remainder of the domestic economy—mainly subsistence agriculture and perhaps a small manufacturing and trading sector, would be unable to respond to this pattern of demand, and growth of the 'internal' economy would be minimally affected by the potential demand existing within the economy.

However, where there is a policy of import-substituting industrialisation as, for example, in India in the recent past and much of Latin America, these goods would eventually be produced within the country. The technology for making these goods is available in the West and could be obtained either by a straight purchase of machinery, through direct investment by a foreign manufacturer or through a joint venture between local and foreign capital. Either way, technology would be imported to manufacture the consumer goods previously imported. Coming from the industrialised world and reflecting the factor endowments of the industrialised world, the manufacturing technology will mostly be highly capital-intensive, and there are few ways of avoiding this. But the issue goes deeper than this. It is no solution to suggest that labour-intensive techniques simply be substituted for the imported capital-intensive techniques. For, as Stewart has pointed out, in many instances the choice of production techniques is ruled out once a choice of product is made:

> '. . . labour-intensive methods in, for example, textile manufacture or brick-making are excluded if *modern* style textiles or bricks of standard and homogenous strength and appearance, are to be produced. The same applies to road-making and iron and steel.'[20]

This is termed by Stewart 'over-specification', which she illustrates as follows:

> 'Some commodities may overkill in relation to a specific need, i.e. provide services in excess of these specified, e.g. if the specified need is for warm clothing a Dior dress may fulfil it but it also provides other characteristics not essential for fulfilment of *this* need.'[21]

So it is important therefore, to consider the problem not just in terms of using appropriate techniques, but also in terms of 'appropriate products'. However, what is produced within a country is not determined by some objective assessment of needs; rather it is the pattern of income distribution which leads to a particular structure of demand biased towards capital and skill-intensive goods for consumption by the upper and middle classes. In short, patterns of income distribution biased towards the middle and upper classes produce a structure of effective demand for products that can only be produced by capital-intensive technologies. The pattern of demand for over-specified goods (inappropriate products) for consumption by the minority rules out the widespread use of appropriate techniques; therefore it follows that labour-intensive techniques will not be generally utilised, and cannot be seen as a means of altering existing patterns of income distribution, patterns which are themselves the basic cause of the widespread use of inappropriate techniques. There is a major contradiction here which, for a strategy based on appropriate technology to be feasible, implies a *prior* redistribution of income. Only when income is redistributed on a more egalitarian basis will the structure of demand shift from goods which can only be produced by capital-intensive means, to goods that can be produced using labour-intensive and appropriate technologies. But labour-intensive techniques cannot be introduced in isolation, to form the basis for greater equality in income distribution and employment. The implication of the argument is that more equal incomes are a *necessary* and *prior* condition for a strategy based on appropriate technologies, and not the other way round.

But of course, the demand for a redistribution of income which will create the conditions for the successful introduction of a strategy based on appropriate technology, is likely to encounter resistance from those wealthy groups who will be disadvantaged[22]. Certainly, many Third World governments have resisted attempts by outside agencies to promote appropriate technologies.

According to Paul Harrison,

> "At the World Employment Conference in 1976 many of the most vociferous and influential governments spoke out against (appropriate technology). In a typical comment, India's Sanjivan Reddy remarked that 'no nation could afford to lose the long-term advantages of modern technology. Excessive dependence on labour-intensive technologies would deprive the Third World of its right to the patrimony of mankind'."[23]

Such arguments clearly express the view, widely held in the underdeveloped world, that appropriate technology is a 'second best' solution that is being foisted on the Third World by the developed countries, in order to preserve the dominance of the west by keeping the underdeveloped countries in a state of technological backwardness. Of course, this argument deserves attention[24], but with Dr E.F. Schumacher it can also be argued that it represents

> ". . . the voice of those who are not in need, who can help themselves and want to be assisted in reaching a higher standard of living at once. It is not the voice of those with whom we are here concerned, the poverty-stricken multitudes who lack any real basis of existence, whether in rural or urban areas, who have neither 'the best' nor 'the second best' but go short of even the most essential means of subsistence."[25]

At the root of such arguments, then, there remains the issue of income distribution, and the issue of who benefits from technological innovation. Some powerful groups within the Third World, who benefit from the use of capital-intensive western technology, may resist the introduction of appropriate technologies insofar as these appear to pose a threat to the *status quo*. In other words, there are obvious social limits on the extent to which appropriate technologies can actually be introduced on a large scale, limits which are defined especially by the existing structure of income distribution in any particular country. This does not mean that no 'appropriate technologies' will be introduced. Rather, it serves to suggest that appropriate technology may do no more than make additions to the existing range of technological choices, and may or may not actually be utilised. It cannot be assumed that once we devise an appropriate technology, then it will automatically be used. And the argument here is that appropriate technologies will probably not be widely utilised without prior redistribution of income. Where such technologies are introduced without such redistribution, then they will probably serve to solve the problems of already wealthy groups rather than the poor, as the case study of energy will illustrate. Thus, under these conditions, 'appropriate technologies' may merely serve to reinforce the *status quo*, since the fundamental conditions governing technological choices, and the social groups making these choices, remain largely unchanged.

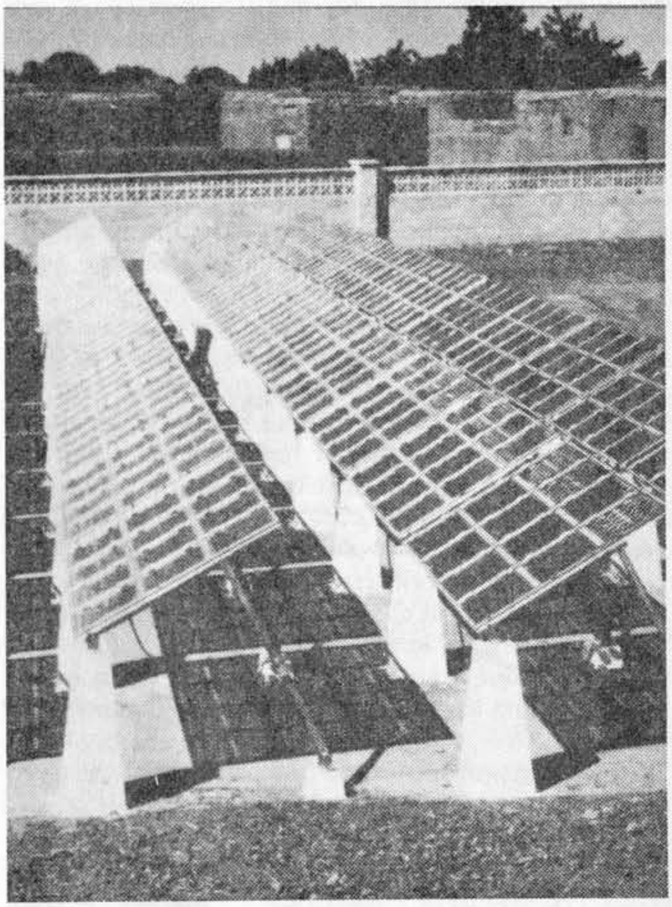
This situation also opens up the possibility of a continued dependence on western technology. Where 'appropriate technologies' are required to solve a problem faced by local wealthy groups, these will be acquired from whatever source possible, and not necessarily from the Third World manufacturers. Significantly, such technologies are becoming increasingly available in the west where, under the impact of changing world economic conditions, the industrialised countries are devoting a considerable effort to the production of 'appropriate technologies'[26]. In a bid to retain or expand markets, many western companies are looking towards the Third World to sell such products and in this effort, are assisted by the aid programmes of the industrialised countries. The impact of this could be extremely disadvantageous in terms of the generation of local solutions to the technological problems of the Third World, expanded employment opportunities and the development of a local manufacturing sector. These points are discussed at greater length in the following section.

The External Dimension: Appropriate Technology and Dependence

The concept of appropriate technology as a basis for development has apparently come to be reflected in official aid programmes in recent years. In 1976, the British Government published a White Paper which announced a re-ordering of its priorities in the allocation of aid, involving a new emphasis on rural development on the basis of appropriate technologies, rather than the provision of capital-intensive techniques for industry and infrastructure[27]. The World Bank groups also came to accept the position that concentration of resources on industry and infrastructure, and the encouragement of capital-intensive technologies in all sectors, had led to severe unemployment and inequality. The Bank announced in a series of publications a re-ordering of its priorities particularly in terms of sectoral allocations, while on numerous occasions Bank officials have referred to the need to concentrate resources on appropriate 'income-redistributing' technologies[28]. These changes in aid policy have been summarised by Jequier, who, echoing an earlier generation of technological optimists, suggests that

> "The growing institutionalisation of intermediate technology will inevitably reflect upon the pattern of foreign aid. Already today, many aid-giving countries and agencies are trying to focus more of their assistance programmes on appropriate technology. This is undoubtedly a positive change and it should allow for a considerable widening of the technology spectrum. In fact, in a few years time, the 'consumer' of appropriate technology will probably find himself in the equivalent of a supermarket with dozens of different tools or technologies to meet every single one of his needs."[29]

However, such an approach has serious implications for the Third World because it could end up by increasing the technological dependency of the underdeveloped countries on the industrialised countries. To look upon overseas aid as a major source of appropriate technologies is to undermine the autonomy and 'self-reliance' which is an explicit goal of appropriate technologies. The concept of self-reliance, which has been an important theme in numerous underdeveloped countries, relates quite critically to



Mazingira

Solar power in Africa: exported from the West.

the issue of the local manufacture and use of appropriate technologies on the basis of a strategy of 'development from within' (i.e. oriented more towards domestic needs rather than international markets) which will generate more jobs and greater equality within the Third World[30]. But self-reliance is diminished in the face of reference to a 'supermarket' of appropriate technologies available under aid programmes, and in the face of the World Bank's strategy of bringing improved technology to still passive recipients[31].

In fact, in the form proposed by western academics and aid-agencies in recent years, appropriate technology has come to represent another 'dependent-oriented' model, which is based on and re-affirms the very relationships which created the structure of underdevelopment in the first place. Indeed, it is quite clear that western aid programmes oriented towards the provision of appropriate technology are largely concerned with creating new export opportunities for developed country industry. For example, the United States Agency for International Development (USAID) allocated US $20 million in the period 1972-78 for the development of appropriate technology, while in 1977 the British Ministry of Overseas Development allocated £500,000 to the Intermediate Technology Development Group for the purpose of developing and disseminating technologies appropriate to Third World conditions[32]. However, the US programme is restricted to subsidising the efforts of US private enterprise in developing appropriate technology for use in the Third World, while both the US and the UK programmes stress the profitability for their respective private sectors in marketing machinery and materials in the underdeveloped countries[33]. If these programmes are symptomatic of the general approach of aid agencies, (and the earlier quote from Jequier suggests they are), then this can only lead to a new technological dependence on western corporate interests. Once again, as the later empirical material makes clear, this is already happening in the field of alternative energy technologies.

Such a situation could mean that, given the resources available to the developed countries, their R & D for appropriate technologies is likely to far outstrip the efforts of the Third World in this area, and could lead to a monopoly of knowledge of hardware for which the underdeveloped countries could pay dearly (as before). Moreover, the manufacturing and marketing skills of western companies are bound to given them the edge over local Third World companies, where these exist. The concentration of these resources in the West could lead to a situation in which the Third World is effectively precluded from developing its own technologies, and generating the local employment and technological autonomy, that is implied by appropriate technology.

Of equal importance is the probability that the direction of that part of the R and D effort which is carried out in the Third World, could be influenced by the fact that a large part of this effort is also financed by aid funds. Perceptions of what is 'appropriate' for the Third World may reflect western concerns, and could influence the direction of the research effort in ways which lead to inappropriate solutions.

In summary, it must be acknowledged that there are dangers (as ever) for the underdeveloped world, in the aid relationship. In this context, the important point is that the west could emerge as a monopoly supplier of appropriate technologies, with control over R and D processes and the direction of research, control through patents or licensing agreements, and a unique knowledge of marketing strategies and conditions, all of which could create a new technological dependence and deny the Third World the benefits of appropriate technology.

All in all, there appear to be major problems with introducing appropriate technologies in the Third World. The existing social structure can act as an impediment to many appropriate technologies, whilst those that are introduced may serve to reinforce the *status quo*, enabling already wealthy groups to improve their position and creating a new technological dependence upon the west. These arguments can be empirically supported by reference to developments in the energy sector.

Energy as an Example

In recent years concern has been expressed at the highest levels about present and future patterns of energy supply and demand. World energy consumption in 1975 was about 5,750 million toe (tonnes of oil equivalent) and in the year 2000 it is estimated that it will be between 15,000 million and 20,000 million toe. At a global level, per capita energy consumption in 1975 was 1.45 toe but there were significant differences between the developed and underdeveloped countries. In 1975 per capita consumption of commercial energy in USA was 7.8 toe and in Europe it was 3.1 toe; yet in the developing countries the average level of per capita consumption was only 0.3 toe. Put more simply, about 30 per cent of the world's population (located in the developed countries) consume about 83 per cent of the available energy[34].

The response to this situation has been to seek to develop alternative energy sources in both the industrialised and underdeveloped worlds. But the problem of alternative energy sources is said to be especially critical for the Third World since a large number of underdeveloped countries are heavily dependent on imports to meet their commercial energy needs, especially oil which, expressed in constant 1974 prices, registered about a seven-fold increase between 1974 and 1980[35]. The balance-of-payments problems that this directly created for many Third World countries was exacerbated by the increased indirect costs of manufactured imports from the developed countries which also rose in price as a result of increased oil prices[36]. Moreover, alternative energy sources are said to be particularly appropriate to the conditions of the Third World, where a major problem exists in financing and constructing energy production and supply systems which will meet the needs of scattered rural populations. In this situation, small-scale, decentralised systems of energy production need to be fostered since, under almost any conditions western technology, based on centralised, capital-intensive energy producing systems designed to serve the needs of highly urbanised societies, is likely to be inappropriate.

As a result, much attention has been focused on new sources of energy, such as solar, wind, wave, geothermal, biomass and methane gas, as well as traditional sources which remain unexploited (e.g. coal, peat) or which can be scaled down to a more appropriate level (e.g. 'mini-hydro' schemes)[37].

The consequences of the use of alternative energy technologies by particular Third World countries for global trading patterns, and in terms of resource usage, can be partially illustrated by reference to the case of the biogas (or gobar gas) plant. This piece of technology utilises animal dung, waste vegetable matter and other unused resources (including, in some countries, human waste) and, through a process of anaerobic microbial fermentation, produces methane gas suitable for cooking and other domestic uses, and also a nitrogen-rich slurry which is an excellent fertilizer[38]. There are several million of these plants in use in China, and some 60,000 were recorded in India by 1978[39]. The following quote reveals the potential of the productive use of such waste matter in the Third World:

> 'The Food and Agriculture Organisation has calculated that in 1970-71 organic wastes available in the Third World contained 103 million tons of plant nutrients — eight times the amount of chemical fertilizer actually used.'[40]

In the particular case of India, the same author notes that

> 'If all the dung of India's livestock, and all human wastes, were fermented, this would meet the domestic fuel requirements of three out of four families and the savings in manure or fuel could be worth $1 billion a year or more.'[41]

Naturally, in many societies there are understandable cultural objections to the use of human wastes in this way[42]. Nevertheless, the use of animal dung and plant materials alone could still provide a massive resource which the biogas plant could utilise in a more efficient manner than at present. To cite the case of India once more,

> 'One third of India's billion tons of cow dung is burned as domestic fuel each year and meets more than half of household fuel needs. This is a tragic waste of the equivalent of more than India's total production of fertilizer.'[43]

The author points out that if dung was first processed in a biogas plant, this would produce methane gas as an energy source and still leave enough organic fertilizer to "produce an extra 10 to 14 million tons of food grains."[44]

From this example, some of the local consequences of the widespread use of biogas fertilizer plants in the villages of India should become clear[45]. There would be a great deal of employment generated in the local construction of biogas plants, and in the supporting services needed to 'feed' and maintain them, distribute the fertilizer locally, and to construct and maintain the distribution system which would deliver the methane gas to the local community. On the global scale, India would be able to reduce the need to import the technology necessary to produce nitrogen fertilizers or the fertilizer itself, with considerable savings in energy use; the western technology consumes energy in the process of fertilizer production, whilst the biogas plant manufactures energy in that process. In addition, the biogas plant would ensure further considerable energy savings in that there would be reduced costs for transport and infrastructure, compared to production in a large-scale centralised western fertilizer plant, with its attendant need to haul large amounts of that commodity from point-of-production to point-of-use. Finally, of course, the adoption of the biogas fertiliser plant means that energy for domestic use is produced where it is needed—at the village level. This then reduces the need to solve the problem of rural energy needs by resorting to the "traditional" response widely adopted in the Third World to date, i.e. to utilise western technology in large-scale centralised electricity generating plants, which deliver energy to far-flung rural communities through an expensive and extensive transmission system[46]. Once more then, the biogas fertilizer plant implies a reduced dependence on western technology, with reductions in imports and large foreign exchange savings.

Table 2

Production of 230,000 tonnes of Nitrogen per year by Western and Alternatives Technologies

	Western Technology	Biogas Plant
Number of Plants	1	26,150 (at 8.8 tonnes per year per plant)
Capital Cost	about $140 million	about $125 million (at $4,825 per plant)
Foreign Exchange	about $70 million	Nil
Capital/Sales Ratio (at $150 per ton nitrogen)	1.20	1.07
Employment	1000	130,750 (at 5 per plant)
Energy	about 0.1 million MWh per year consumption	6.35 million MWh per year generation

Source: A.K.N. Reddy, 'Alternative Technology: A Viewpoint from India,' *Social Studies of Science,* No. 3 (1975), pp. 331-42.

The extent of such savings is not known, although Reddy calculated in 1975 (see Table 2) that to produce 230,000 tonnes of nitrogen fertilizer per year would require some 26,000 village level biogas plants, which would involve savings on capital cost of $15 million, and foreign exchange savings of $70 million, when compared to the same level of production from one urban, coal-based plant utilising western technology.[47] A crude extrapolation from this figure suggests that the 60,000 biogas plants currently in use have probably involved savings of over $160 million in foreign exchange. It can also be calculated, albeit very approximately, that if all the 2,150,000 tonnes of nitrogen fertilizer used in India in 1975-76, which constituted 64 per cent of all fertilizer consumption,[48] were produced in biogas plants, the foreign exchange savings (in 1975 prices) would have been in the order of $651 million. However, this would have required nearly 250,000 biogas plants, which is obviously many times the number in current use in India, although only a fraction of the 5 million plants reportedly in operation in China.

Clearly, the consequences of utilising alternative energy sources, of which biogas is only one, are very considerable, both for the industrialised world which would apparently experience a reduction in exports of conventional energy technologies, and for the underdeveloped countries which would appear to gain in terms of capital and foreign exchange savings, the generation of many more employment opportunities, and a loosening of the links of technological dependence which tie the Third World to the west.

However, it will be argued that, for a variety of reasons, these apparent gains and losses will be difficult to realize; appropriate energy technologies hold out the prospect of immense benefits to the Third World, but political and economic factors combine to inhibit the effectiveness of policy in this area. To analyse this further, it is necessary to consider the nature of the energy crisis in the Third World, and the responses to this in both the developed and the underdeveloped countries.

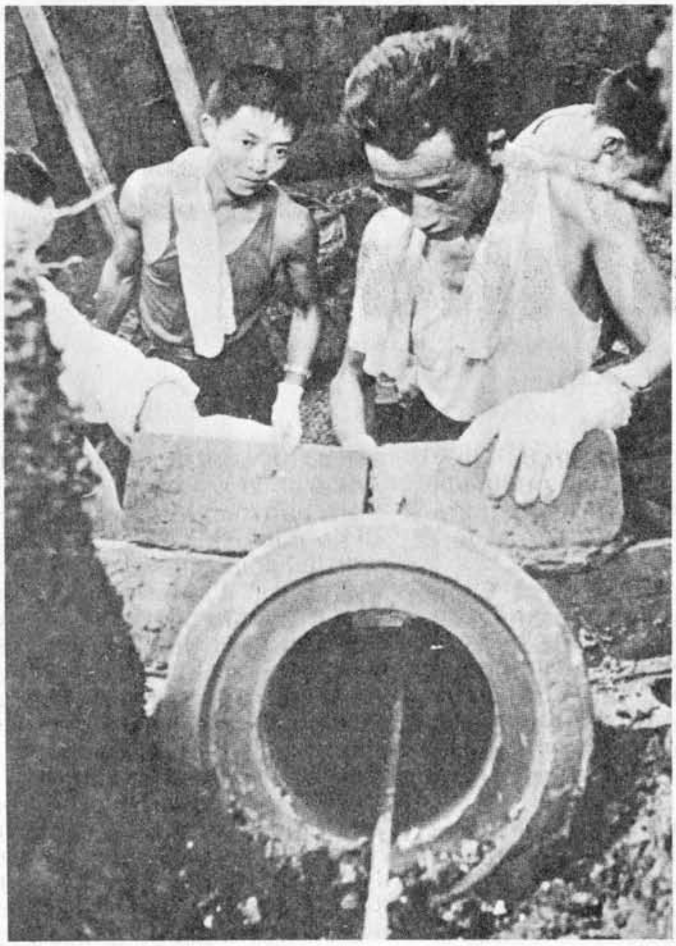
The Energy Crisis in the Third World

In much of the literature on the energy crisis and the Third World, the problem is defined as essentially the same problem which has so affected the industrialised countries in recent years, namely the increased costs of commercial energy, especially oil. As a result, it is frequently assumed that the solutions which are appropriate to the west are also appropriate to the Third World. However, both of these propositions are arguable, and in fact it is clear that the energy crisis in the Third World is different, and revolves around shortages and usage-inefficiencies of non-commercial traditional fuels such as wood fuel, animal dung and crop residues. It is these, and not the commercial fuels so critical to the industrialised countries, which account for the greatest part of energy consumed in the Third World today, and are the dominant energy source in most rural areas of Afria and Asia. For instance, fuelwood, consumed either as charcoal or firewood contributes 96 per cent of all energy consumed in Tanzania, 91 per cent in Nigeria and 90 per cent in Uganda. Many observers feel that this extensive dependence on traditional fuels, particularly firewood[49] is the major energy problem Third World countries are likely to face over the next ten years. The commercial energy forms, which underlay the energy crisis in the west, account for only a relatively small percentage of total energy consumed in the Third World, and commercial energy meets the energy needs of only a small fraction of the population in developing countries. Demand for commercial energy is highly concentrated in the urban areas, particularly in the transportation (largely private cars) and industrial sectors. Urban areas typically contain only a relatively small percentage of the total population—but this percentage usually accounts for the overwhelming majority of upper income groups in the country. In Africa, for example, only 10 per cent of the population, usually the wealthiest 10 per cent, lives in urban areas, and they consume 95 per cent of all commerciai fuels used in the country.[50]

Not only is the energy crisis of the Third World different from that of the industrialised countries, but clearly it differs also between rural and urban areas within the Third World. However, it appears to be the case that the technical solutions to the "energy crisis in the Third World" are being determined without reference to the varying problems that face different groups within the Third World, but rather by the technical characteristics of alternative energy sources. For example, although detailed statistics are difficult to come by, it appears to be the case that the main orientation of R and D in the Third World is (as it is in the west) towards solar energy for the domestic sector, and for crop drying, powering irrigation pumps, and so forth.[51] However, this emphasis is difficult to explain. It is not yet obvious that solar energy systems are the most suitable or appropriate for the rural areas of the Third World. While it is true that such systems do have a number of technical characteristics which may be appropriate to rural areas, so do many other systems. Unfortunately, there have been few attempts to carry out field-based economic, social and technical evaluations of *competing* alternative energy technologies. The more usual situation discussed in the literature is one where pilot projects are evaluated either individually or else are compared against other systems on the basis of data drawn from laboratory or theoretical conditions.[52] Clearly this is inadequate, and any sizeable investment in the production and distribution of solar energy systems should only be considered after full and comparative evaluations have been calculated.

The current emphasis on solar technology may or may not prove eventually to have been correct, but what is certain is that research priorities will not have been determined by an analysis of the socio-economic problems of the rural poor. Neither solar, nor any other alternative technology, can be evaluated on the basis of technical criteria alone; when they are, as is frequently the case with the advocates of appropriate technology who define the problems of the Third World as essentially concerned with the *level* of technology, then the poor generally lose out.

For example, there is a widespread assumption in the field that low levels of energy consumption in the rural areas are due to inadequate supplies of energy (for instance due to deforestation). The policy response by many aid agencies and national governments to this perception of the problem has been one which concentrates on increasing the supply of energy. This has been affected largely by introducing (or proposing) new technical systems designed either to improve the conversion efficiency of currently used fuels such as wood, or to open up previously untapped sources of renewable energy such as solar power or biomass.[53] In fact, rather than being a problem of inadequate supply, it is more likely that the problem is one of demand in which low incomes prevent many of the rural poor from acquiring sufficient energy for domestic or production purposes.[54]. Income distribution is highly skewed in rural areas with much of the population existing on incomes which are close to subsistence. Lack of income is in turn related to little or no land ownership, inadequate access to credit and extension services, and low levels of technological sophistication. Any rural development programme which does not take explicit account of the distorting nature of these structural problems bears little chance of bringing benefits to those who need it most. The implications of this situation are that many (relatively expensive) technical interventions such as the introduction of solar energy



In China biogas plants are built and operated for the local community. Everyone shares the benefits.

systems will only benefit the wealthier fraction of the rural population who can afford the costs involved or who do not have more urgent uses for their money incomes. A policy of income redistribution, on the other hand, will mean that the poor will have the material resources to express their demands (which may be for a technology other than solar). However, without structural changes which increase rural incomes and convert basic needs into effective demands, and research which relates these demand to technical possibilities, then the *purely technical* solutions offered by the appropriate technology movement remain irrelevant to the mass of the rural poor.

This is true not only of the solar energy technologies which are emerging as the dominant form of alternative energy and which (as will be seen) largely rely upon western sources, but it is also true of locally-manufactured technologies, such as the biogas fertilizer plant. Despite its obvious technical merits it is clear that the biogas plant has only benefited the already-wealthy groups in rural India, and has disadvantaged the poorest:

> "widely touted as a truly appropriate technology, in fact biogas plants have, so far, been used only by the rich farmers because of the high capital costs required and the fact that even the smallest plant requires the dung from two cows. Furthermore, biogas plants mean that dung, which previously was free, now has a cash value and landless villagers can no longer pick it up easily off the road."[55]

Commenting on this, A.K.N. Reddy, an Indian scientist who has long advocated the use of these plants, now confirms that

> "The villagers are in no position to buy biogas plants (so) they will end up with no fuel at all—in other words, their position will be worsened by the introduction of biogas plants."[56]

Such outcomes are not necessarily associated with the nature of the technology involved, but with the social context of technology, especially the pattern of ownership which prevails. None of the outcomes observed in India have occurred in, for example, China, where many more biogas plants are in use, but where they are communally-owned and operated for the benefit of the whole village. This suggests that similar approaches might be more appropriate elsewhere, and that in paying attention to issues of ownership as well as the level of technology, there might be a need to consider technological solutions which imply community ownership rather than individual ownership.[57]

However, current conceptions and formulations of appropriate technology still broadly assume that the existing social and economic problems of the poor of the Third World are solvable by measures which are essentially of a technical nature. This derives from the fact that the approach from appropriate technology is essentially a "technicist" one which suggests that the critical factor in determining the spread of benefits from technology throughout the community is the *level* of the technology involved. However, it is clear that the issues of ownership, of income distribution and so forth, are also important and that under certain conditions, increasing the supply of energy through the provision of biogas plants or solar energy units does not solve the energy problems of the poorest of the poor; the reverse, in fact, can occur when purely technical solutions are offered which take no account of the underlying social structure in many Third World countries.

This approach is also creating the possibility of a new technological dependence on alternative energy sources, which threatens to replace existing forms of dependence on western technology. The search for purely technical solutions is bound to lead many Third World countries to look to the industrialised world for sources of technology, since the developed countries have an undoubted technical superiority in the field, and are more than willing to expand their operations in the Third World. However, this strategy has serious implications for Third World countries, as the following section reveals.

Alternative Energy Technology: A New Dependence

While the Third World has, in recent years, begun to undertake research and development (R & D) work in alternative energy sources, this effort is already being swamped by the research carried out by the industrialised world as a response to its own energy crisis. It is difficult to give precise figures, but as regards solar energy, which undoubtedly accounts for the bulk of global R and D expenditure on alternative energy sources, around $500 million was spent worldwide in

Electricity Comes to Rural India

How odd that the coming of electricity in a village is taken as a sign of development. How strange that everybody — planner, implementor, politician — considers electrification as the final solution to all the problems of Rural India. How extraordinary that they all think alike on what development means — an increase in acreage under cultivation, in the energisation of wells, in the use of high-yielding variety of seeds and chemical fertilisers and pesticides in the mechanisation of farm practices: we know them all by now surely. How tragic that the people who matter continue to ignore the rural realities — the real issues!

These experts, in the same breath, also talk in terms of social justice, of equal opportunities to all and economic equality as promised by the Constitution if you please. Now, where does one start picking holes in the present strategy and way of thinking that makes a mockery of the development process? That is the problem.

The statistics that the Directorate of Extension has given us for 1981 should be an eye-opener: out of the total farming population, 78 per cent are small marginal farmers; hence more than 350 million farmers in India own on average, three hectare and less. Most of them are involved in subsistence farming, and are the least likely to have the wherewithal to buy electric pump-sets, go in for high-yielding varieties of seed and bother about mechanisation because the degree of technology involved is beyond their imagination and experience. In fact, for small land holdings the most practical way is to use a pair of bullocks for irrigation as well as for ploughing.

Moreover some 90 per cent of the marginal farmers have not changed from their traditional farming practices — and with good reason too. If they need to locate a well site, they go to the water diviner instead of the geophysicist. They prefer a pair of good animals to a pumpset (Rs.4000) for irrigation or to a tractor (Rs.60,000) for ploughing. They prefer farm manure to chemical fertiliser: for seed they choose the local variety because they understand it better.

You speak to anyone of them about electric pumpsets and see the reaction. Our experts in rural development sitting in air conditioned comfort have no idea of the heart felt needs of the small and marginal farmer, the rural artisan, the scheduled caste villager, the Harijan.

Instead what happens is that while the income of the bigger farmers increases because of assured irrigation facilities under the rural electrification programme the status of small and marginal farmers progressively declines. Pressures are put on them from all fronts. On the one hand they have to withstand the vast resources of the bigger farmers and money-lenders and their desire to acquire more land; on the other hand the government's insistance that they discard traditional practices and use high-yielding varieties of seed while being provided with too little water, has made them vulnerable and demoralised. Consequently the sale of land has increased to better-off farmers, in itself one of the major causes of migration from the rural to urban areas.

Thus the small and marginal farmer, owing to circumstances beyond his control, is gradually becoming a subsistence farmer and then a landless labourer. Prof. Raj Krishna has calculated that one out of every four Indians is an agricultural labourer whose standard of living is among the lowest in the country.

Is this what India's rural electrification programme is supposed to be doing? In fact although it may have given India more food, rural electrification has proved to be a facility enjoyed exclusively by the richer farmers, the landowners, the money-lenders. They have built fancy houses, bought more tractors, constructed more wells and literally bribed the system, along with the village level government functionaries, to work for them. I am not being unfairly severe in my criticism here because I have seen the ruin of poor families wanting to keep up with the Joneses and never recovering from it. I see the mad rush for electric connections now in Tilonia, yet if we tell them of the lessons that can be learnt from the experience of farmers in Haryana and Punjab, they think we are trying to deprive them of a gift.

Who Learns from Experience

In Punjab and Haryana the power pumping of tube wells has critically affected the water balance, especially where more water has been pumped out than is recharged. Furthermore the water has become saline. Not only that, farmers have to irrigate their fields at unearthly hours because of severe power rationing at other times.

In and around the Tilonia area (Silora Block) Ajmer district, Rajasthan, within a radius of 20 kilometres there are over 300 open wells in a hard rock area where geophysical surveys have shown that the rate of recharge is suspect. With traditional methods of irrigation it was possible to maintain the water balance, now that electric pumpsets are being installed in nearly all those wells, two consequences are likely: either that wells will dry up, or that the water will become saline.

Why Electricity?

What is special about the bulb that it must replace the lantern? Villages have been doing without it for years and many will have to remain in darkness. That only one out of every 10 homes and huts in India has electricity and two—thirds of the 500,000 villages have no connections speaks for itself. Why, even in villages where — the government claims — there is electricity, many primary and middle schools, dispensaries, panchayat ghars, post offices, railway stations, police posts, temples, literacy and family planning centres are still functioning without electricity. More important traditional items — matkas (potter), ploughs (blacksmith), shoes and leather buckets for irrigation (Regars), cloth (weaver) and bullock carts (carpenter) — for village needs, still exist but not without casualties. The coming of electricity has thrown thousands of rural artisans out of jobs.

We talk of self-sufficiency in villages. There was a time when villages were self-contained units consisting of different communities but all dependent on each other. Nothing was imported from outside. With electricity, however came small scale industries and cheap goods; mass production, standardisation and the disappearance of centuries old skills.

Plastic has come to stay — plastic glasses and plastic shoes which neither the potter nor the Regars can compete with; tractor and cultivators from big factories are constantly providing a contrast to the wooden plough; and blacksmiths are getting harder to find, though many of them have changed with the times and started making cultivator shoes.

No longer do many farmers go to the Regars to get their leather buckets made or repaired — not after the installation of pumpsets. Power looms and terelene have made handloom cloth dearer. Our champions of this type of development should take some time off to see how weavers in pit looms are struggling to keep alive.

Is this the sort of development we have in mind? Do we want rural electrification at the cost of the rural poor who we thus deprive of land, leaving them little choice but to migrate? Do we want to encourage unemployment, and destroy traditional skills, thus increasing economic disparities and allowing the system to exploit the depressed minority groups?

Postscript:
Tilonia got electricity the other day and a Minister was invited to inaugurate the event. Just as he was about to press the switch, someone in the crowd threw a stone at the bulb and broke it.

Bunker Roy

1978, of which the United States alone accounted for 60 per cent.[58] At the moment, it appears that government expenditures account for the greater part of research into alternative energy sources, although the private sector has undertaken its own R and D as well as benefiting from government research in this area.[59] A part of the funding being made available by western governments for research into alternative energy sources is explicitly directed towards the Third World, through the provision of research funds and technical personnel under western aid to the underdeveloped countries. At the same time, western governments have developed policies which link programmes of official aid to "appropriate" technologies being developed in the West, which has enabled private corporations to penetrate markets for alternative energy technologies in the Third World. Certainly, the United States has stongly emphasised the role of the private sector in the alternative energy programmes of the underdeveloped countries, to be supported by official aid, and there is strong evidence that the European Community is under pressure to adopt a similar approach in aid for alternative energy technologies in those Third World countries associated with it under the Lomé Conventions.[60] Without denying that the private sector within the industrialised world may have some part to play in developing and disseminating alternative energy technologies for use in the rural areas of the Third World, nevertheless it must be recognised that this situation has serious and probably detrimental consequences for the recipient countries.[61]

Firstly, with the provision of aid funds and technical personnel to support research into alternative technologies for the Third World, it is likely that the aid agencies will be a significant source of funding, and consequently could influence the direction of the research orientation. For example, the experience and orientation of the developed countries is undoubtedly towards solar energy systems for use in solving their domestic energy problems, and this is receiving considerable emphasis in aid programmes. However, it was argued earlier that the research orientation in the Third World ought to be directed to other alternative energy sources, as well as solar energy (and analysed in the context of an overall framework for rural energy policy which encompasses economic, social and cultural factors, as well as the wider goals of rural development policy). At the moment, though, the R and D effort of the Third World appears to mirror that of the industrialised countries rather than being designed to resolve the energy crisis as it manifests itself in the Third World, and analysing the social context of that crisis. To repeat, it may eventually prove to be the case that solar energy technology is highly appropriate to the Third World. But this has to be subjected to a comparative analysis and a social evaluation, and the blandishments of western salesmen resisted until such studies have been conducted. Otherwise it may be that the only problems which are solved are those of western companies eager to sell solar technology to the Third World until such times as domestic markets are enlarged, within the Third World and those of wealthy groups who are able to purchase this relatively expensive technology as a substitute for costly commercial energy sources. For it has been argued that the current trends in research, production and marketing of alternative energy sources mean that a new technological dependence in energy is emerging, which simply replaces a previous dependence upon the western technology for the conventional production and distribution of energy, mainly electricity, through the use of large-scale, centralised generating systems and extensive distribution networks. The fact that the industrialised countries account for the greater part of R and D into alternative energy sources means that the technical knowledge necessary to tape these resources is being concentrated in the industrialised countries rather than the Third World. Encouraged by western governments which are providing aid in support of research into, and sales of, alternative energy systems (mainly solar and possibly inappropriate) to the Third World, western corporate interests are coming to dominate in the areas of alternative energy sources. This whole situation is summed up by Hoffman thus:

> "... a massive inequality is being built up in the international distribution of capabilities relevant for the exploitation of alternative energy technologies. The pattern of R and D expenditures indicates that substantial research and development capabilities are being accumulated in a handful of industrialized economies, and that their scale far outweighs those being accumulated in the whole of the Third World. The emerging overwhelming strength of the industrialized economies in this area of technology is being carefully hooked into the existing structure of relationships between advanced and developing economies. Commercial enterprises and public bodies which fund the development of alternative energy technology already have their eyes on the markets of the Third World. Links are already being forged between aid agencies and the developed country suppliers of technological services relating to non-conventional energy, as are links between aid agencies and developed country suppliers of goods and systems. At the same time, joint projects between developed and developing country institutions, together with training courses organized by the former are being planned and operated. To some extent, at least, professionals from the Third World are being informed and oriented by the directions of technological development occurring in the developed countries."[62]

This inevitably means the substitution of foreign technological capabilities for local capabilities, denies local research institutes and entrepreneurs the opportunity of developing indigenous production facilities, and therefore denies the Third World much of the potential that appropriate energy technologies hold out for local manufacture, local employment-creation and local technological autonomy. Clearly, these issues must be seriously considered by the Third World as it begins to tackle its critical energy problems.

Policy Issues in Appropriate Technology

This paper has, so far, drawn attention to a number of major issues in the field of appropriate technology. It has concentrated on social and political factors, rather than technical problems, since the former are frequently ignored. But clearly, the socio-economic factors are critical. The success or failure of appropriate technologies depends upon a whole range of social factors and human actions; the technical problems are often easily solved, while the social ones are frequently more problematic.

Given this, it is not the intention of this paper to tabulate a list of policy recommendations, or outline specific science and technology policies. Rather, it is proposed to draw attention to a limited number of issues, some of which have been discussed in this paper, which need to be at the centre of policy formulation, and need to be borne constantly in mind by those responsible for formulating and executing policy. This list is not necessarily complete and does not claim to cover all the important issues.

1) The issue of income distribution is clearly of major importance. Most Third World governments have a commitment to the redistribution of income from rich to poor. If a strategy of appropriate technology, with all that that implies for the well-being of the Third World, is to be realised, there must be firm government action to follow this through. There are few countries where such redistributive policies have been implemented, except insofar as the position of the poor has worsened, and that of the wealthy improved. This trend has to be reversed if appropriate technologies are to be successful.

2) The issue of ownership is also of equal importance. As far as is possible, appropriate technologies ought to be owned and controlled by community organisations, e.g. the village, the rural cooperative, etc. This is the most certain way of ensuring that the community as a whole benefits from appropriate technology. It implies, perhaps, a different level of technology, i.e. a larger-scale or more capital-intensive level of technology, but this need not be a problem if it can be financed by the benefiting community. In addition, it may involve the Third World in an R and D effort involving research into more advanced technologies than is often implied by the appropriate technology movement. This might lead to the rejection of the charges that the Third World is being foisted-off with a primitive, second-rate technology, and may also succeed in involving the full commitment of the local scientific community.

3) Research and development expenditures need to be increased in order to generate as much indigenous appropriate technology as possible. More importantly, perhaps, existing research and development needs to be reviewed in order to ensure that limited funds are allocated appropriately, i.e. that the emphasis be directed towards mission-oriented, problem-solving R and D at an appropriate level, rather than pure research determined by the parameters of the western scientific community or the research needed to solve the problems of wealthy social groups. This further implies a review of science and technology education, and the introduction of changes which (over the medium to long-term) make it more relevant to the context of the Third World.[63]

4) There is a need for regional cooperation in R and D amongst Third World countries facing similar problems. The duplication of the research effort can only lead to a waste of scarce resources, and cooperation may allow countries to specialise in different technologies on the basis of a comparative advantage. This could lead to increased and more efficient production, a wider range of choices in appropriate technology, and increased trade within the Third World.

5) If specialist appropriate technology units or research centres are established, they need to be interdisciplinary, drawing on the social scientist as well as the technologist. A strong commitment to the welfare of the rural poor is necessary, and long-term field-work vital, in order to ascertain the nature of a problem, to conduct pilot studies which monitor the social, political, technical and economic consequences of particular innovations before they are applied nationally, and to ensure that the cultural distance between the rural poor and the urban researcher is minimised.

6) At the governmental level, it is necessary to draw together all of these strands into a coherent policy for science and technology, which specifies the goals to be met, the priorities to be established, the institutional means to execute policy, the resources (financial and human) to be made available, the social and economic policies to be pursued, and so forth. In the absence of such a policy, or a failure of the political system to carry it out, the chances of the successful adoption of a strategy of development based upon appropriate technology, with all the benefits to the Third World that such a strategy implies, will be minimal.

References

1. These points are taken from various papers in Ruth Gruber, (Ed.), *Science and the New Nations,* Basic Books, New York 1961.
2. P.M.S. Blackett, "Planning for Science and Technology in Emerging Countries", *New Scientist,* Vol.17, No.326 (14 February 1963).
3. Charles Cooper, (Ed.), *Science, Technology and Development,* Frank Cass, London 1973, Introduction.
4. The World Bank calculated that the outstanding public and publicly guaranteed debt of 81 underdeveloped countries rose from $22,000 million in 1962, to $60,000 million in 1970. More importantly, the increase in debt servicing (or repayments on past loans) rose from $2,600 million in 1962, to $5,300 million in 1969. Return flows on aid, as a percentage of gross lending, rose from 30% in 1966 to 48% in 1970. See John White, *The Politics of Foreign Aid,* The Bodley Head, London 1974, p.55.
5. International Labour Office, *Towards Full Employment: A Programme for Colombia,* Geneva, 1970: *Matching Employment Opportunities and Expectations: A Programme of Action for Ceylon,* Geneva, 1971; *Employment, Incomes and Equality: A Strategy for Increasing Productive Employment in Kenya,* Geneva, 1972; and *Growth, Employment and Equity: A Comprehensive Strategy for the Sudan,* Geneva 1975. An Oxfam report, *Unemployment: The Unnatural Disaster,* (Oxford, n.d.), based on the work of Hans Singer and others, stated that in the underdeveloped world as a whole, open unemployment stood at 25-30% of the workforce in the 1970's.
6. This is discussed in the ILO reports, op. cit. Data on income distribution in the Third World and elsewhere is to be found in S. Jain, *Size Distribution of Income: A Compilation of Data,* World Bank, Washington 1975.
7. Cited in Susan George, *How the Other Half Dies,* Penguin, Harmondsworth 1976, pp.235-6.
8. This is also discussed at various points in the ILO publications already cited. See also K. Marsden, "Progressive Technologies for Developing Countries", in R. Jolly, (Ed.), *Third World Employment,* Penguin, Harmondsworth 1973.
9. G. Arrighi and S. Soul, "Nationalism and Revolution in Sub-Saharan Africa", in R. Miliband and J. Saville, (Eds.), *The Socialist Register,* Merlin Press, London 1969.
10. See the data in Jain, op. cit., where this is statistically demonstrated in many Third World countries.
11. C. Vaitsos, "Bargaining and the Distribution of Returns in the Purchase of Technology by Developing Countries", in H. Bernstein, (Ed.), *Underdevelopment and Development,* Penguin, Harmondsworth 1973; and C. Vaitsos, "Patents Revisited: Their Function in Developing Countries", in Cooper, op. cit.
12. See Sussex Group, "Science and Technology in Less Developed Countries", in Jolly, op. cit., pp.354-65.
13 A. Herrera, "Social Determinants of Science Policy in Latin America", in Cooper, op. cit.; and F. Sagasti, "Underdevelopment, Science and Technology: The Point of View of the Underdeveloped Countries", in E. and V. Rabinowitch, (Eds.), *Views of Science, Technology and Development,* Pergamon Press, London 1975.
14. "Studies by the UNCTAD revealed that in 1972 only 200,000, or 6% of the world's 3.5 million patents were held in developing countries. Of these, only 30,000—less than 1% of the global total—were held by nationals of these countries. The other 170,000 were held by foreigners, mostly multinational companies", cited in Paul Harrison, *The Third World Tomorrow,* Penguin, Harmondsworth, 1980.
15. N. Jequier, (Ed.), *Appropriate Technology: Problems and Promises,* OECD, Paris 1976.
16. This summary is taken from a wide range of sources on appropriate technology, especially E. Schumacher, *Small is Beautiful,* Abacus, London 1974; Jequier, op. cit.; David Dickson, *Alternative Technology,* Fontana, London 1974; Harrison, op. cit.
17. Cited in Z. Sardar, *Science, Technology and Development in the Muslim World,* Croom Helm and the Muslim Institute, London 1977, p.126.
18. For an idea of the scale of such costs, see Vaitsos, op. cit.
19. This discussion is drawn mainly from the introduction by C. Cooper in Cooper, op. cit.; Frances Stewart, "Choice of Technique in Developing Countries", in Cooper, op. cit.; Frances Stewart, *Technology and Underdevelopment,* London, Macmillan 1977; J. Weeks, "Does Employment Matter?", in *Third World Employment,* (Ed.), R. Jolly et al, Harmondsworth, Penguin 1973; and R. Kaplinsky, *Political Economy of Labour-Intensive Technologies,* Institute of Development Studies, University of Sussex, 1973, mimeo.
20. Stewart, in Cooper, op. cit., p.109.
21. Ibid, p.109.
22. For example, it has been calculated by India's Planning Commission that to create every twenty new jobs, there has to be a transfer of income of Rs. 1 million (or £65,000 or US $120,000) from the rich to the poor. Cited in Harrison, op. cit., p.154. Clearly, in order to solve India's massive problems of unemployment and undervelopment, there would have to be an unprecedented shift in the distribution of income from rich to poor, which would appear to be in opposition to recent trends as well as involving considerable political risks. Under existing conditions, it is difficult to see any government of India, or elsewhere, pursuing such a policy.
23. Harrison, op. cit., pp.154-55. This rejection of appropriate technology is reflected in the statement by a director of the United States Agency for International Development, John G. Gilligan, who said on a visit to Asia that ". . . problems could arise from the reluctance of Third World governments to make 'very difficult' political and economic decisions on the distribution of US aid that is now being redirected from large capital-intensive projects to agricultural production, public health and education." *Asian Wall Street Journal,* 16 January 1978.
24. For a discussion of this view see B. Radhakrishna Rao, "Two Faces of Appropriate Technology", *Mazingira,* Vol.4, Nos. 3/4, 1981.
25. Schumacher, op. cit., p.151.
26. As well as the examples in the energy area, discussed later, see also the cases cited in Dickson, op. cit., p.171-73. Such instances, which Dickson argues are still not really appropriate for the Third World, include the package of inputs known as the "Green Revolution". Some of the causes and consequences of the interest shown by the industrialised countries in the Green Revolution technology and other agri-business developments have been discussed in George, op. cit., parts 2-3.
27. Cmnd. 6270, *The Changing Emphasis in British Aid Policies,* HMSO, London 1976; see also Ministry of Overseas Development Paper No. 8, *Appropriate Technology,* HMSO, London 1977.

28. For details of these new initiatives, see World Bank, *The Assault on World Poverty,* Johns Hopkins University Press, 1975; and H.S. Chenery et al, *Redistribution with Growth,* Oxford University Press, 1974. See also H.B. Dunkerley, "The Choice of Appropriate Technologies", *Finance and Development,* Vol. XIV, No. 3 1977, pp.36-39.
29. Jequier, op. cit., p.111.
30. For a discussion of some of these issues see H. Singer, *Technologies for Basic Needs,* International Labour Office, Geneva 1977.
31. George, op. cit. ch. 10.
32. See C. Baron, "Appropriate Technology Comes of Age: A Review of Some Recent Literature and Aid Policy Statements", *ILO Review,* Vol.117, No.5, 1978.
33. Ibid.
34. All figures cited in D. Burch and K. Hoffman. "The EEC and Energy Aid to the Third World", in C. Stevens (ed.), *The EEC and the Third World; A Survey,* Hodder and Stoughton/-Overseas Development Institute/Institute of Development Studies, London, 1981.
35. Peter Odell, "Energy Policies in the EEC and their Impact on the Third World", in Stevens, op. cit., p.85. According to UNCTAD figures, oil imports by the Third World amounted to $29 billion, or just under 15% of their total imports in 1975. See UNCTAD Secretariat, *Energy Supplies for Developing Countries: Issues in Transfer and Development of Technology,* UNCTAD, Geneva 1978, p.14.
36. Tony Killick, "Eurocurrency Market Recycling of OPEC Surplus to Developing Countries: Fact or Myth?", in Stevens, op. cit., p.93. Killick points out that the prices of manufactured imports to underdeveloped countries rose by 40% between 1973-75, although not all of this was due to oil price increases.
37. Burch and Hoffman, op. cit., p.107.
38. See A.K.N. Reddy, "Alternative Technology: A Viewpoint from India", *Social Studies of Science,* Vol. 5, No. 3 (1975); Harrison, op. cit., pp.143-6; UNCTAD Secretariat, op. cit., pp.92-4. A Barnett, et al, *Biogas Technology in the Third World; A Multidisciplinary Review,* IDRC, Ottawa 1978.
39. Harrison, op. cit, pp.144-6. This author suggests that around 5 million biogas plants were in operation in China in 1977.
40. Ibid, p.101.
41.42. Ibid, p.145-6.
43.44. Ibid, p.144.
45. For statistics on the overall benefits of this technology, see Reddy, op. cit.
46. According to the World Bank, some 60-80% of all public sector energy investments in the Third World are usually aimed at increasing centralised electric power capacity. See World Bank, *Rural Electrification,* Washington DC, 1975.
47. Reddy, op. cit.
48. Ministry of Information and Broadcasting, *India: A Reference Annual 1977-78,* Government of India, New Delhi 1978, p.211.
49. See E.P. Eckholm, *The Other Energy Crisis: Firewood,* World Watch Institute, Washington DC, (1975).
50. Cited in: Burch and Hoffman, op. cit. p.109.
51. UNCTAD Secretariat, op. cit., pp.90-91; Kurt Hoffman, "Alternative Energy Technologies and Third World Rural Energy Needs: A Case of Emerging Technological Dependency", *Development and Change,* July 1980.
52. Barnett, et al, op. cit.
53. See, for example, J. Howe, et al., *Energy for the Villages of Africa,* Overseas Development Council, Washington DC, 1977; I.H. Usmani, "Power to the Villages", *Mazingira,* No. 6, 1978.
54. This situation is analagous to that which has occurred with the introduction of high-yielding varieties of wheat and rice in Asia. While the supply of these commodities has undoubtedly increased as a result of the 'Green Revolution', nevertheless the poor of Asia are frequently consuming less than they did 10 years ago, because they have experienced little growth, or have experienced a sharp fall, in real incomes, while the price of rice and wheat has risen dramatically. See, for example, the cases cited in *Poverty and Landlessness in Rural Asia,* ILO, Geneva 1977. Quite simply, in the case of food, the poor do not have the income to purchase their needs, regardless of the supply situation, and there is no evidence to suggest that this will be any different in the case of energy.
55. J. Hanlon, "Does Appropriate Technology Walk on Plastic Sandals?" *New Scientist,* Vol. 74, No. 1053, 26 May 1977.
56. Ibid. It has elsewhere been calculated that it requires the dung from 4-5 cows to maintain a family-sized biogas plant, while capital costs stand at $200-300. Even so, few Indian families would own that many cows, while less than 14% of rural households could afford the capital costs. See UNCTAD Secretariat, op. cit., p.93.
57. Harrison, op. cit., p.145. However, communal plants also have their problems. As Harrison points out, "... Indian culture and politics have proved formidable obstacles. The villages are fragmented into rural factions, cutting across caste lines, which compete for advantage ... Farmers who own cattle are reluctant to hand over their dung for the benefit of the community, as the opposing faction would also benefit ..." Harrison, op. cit., pp.145-6. For a further critique of biogas plants, and the problems of communal ownership, see R. Disney, "Steady Reddy", *Undercurrents,* No. 16, 1976.
58. UNCTAD Secretariat, op. cit., p.90. Hoffman demonstrates that in 1977 a number of other industrialised countries accounted for about 10% of global R and D into solar energy, clearly demonstrating the growing concentration of solar energy R and D in the developed countries. For example, by 1980, the US government expenditure on solar energy research had risen to $800 million. See Hoffman, op. cit., pp 343-50.
59. Ibid, pp. 343-50. For the most part, alternative energy technologies, including solar power, are also being concentrated in the hands of a few large corporations, including several of the major oil companies. See *The Weekly Guardian,* 26 June 1977; 3 July 1977; and 29 October 1978
61. Much of what follows concerning a new dependence on alternative energy sources is drawn from Hoffman, op cit.
62. Ibid, p. 345. See also A. Mackillop, 'Soft Energy: Hard Sell by TNC's in Developing Countries', *Mazingia,* Vol. 4, Nos. 3/4 1981.
63. See, for example, the type of science education received by undergraduates at the University of the South Pacific, discussed in J.W. Twiddell, "Appropriate Technology in University Education", a paper presented at the Third Inter-Congress of the Pacific Science Association, Bali, July 1977.

This paper was delivered at the CAP Seminar on Appropriate Technology, Culture and Lifestyle in Development, Universiti Sains Malaysia, Penang.

Land for Energy Or Land for Food?

by R. Neil Sampson

Executive Vice President, Soil Conservation Society of America

Increasing interest in biomass fuels in the United States and the money to be made from them could put excessive pressure on available cropland. Food could be the loser.

Competition for the use of land is nothing new—it has been a feature of the human struggle for millenia. But seldom has such a totally new set of competitive forces been unleashed on the land as those that appear on the horizon in the declining decades of the petroleum era. As America, and the world, searches for new sources of industrial materials and fuels to replace increasingly expensive, scarce, or unreliable sources of the past, the major focus of attention has turned to agriculture.

New types of farm-grown energy, liquid fuels and industrial materials are technically possible, politically attractive, and increasingly economically feasible. For the first time in history, farm-grown industrial products appear to offer serious economic competition for the use of available farm land and water. Whether or not these new competitive forces are manageable, in terms of the market economies and land use traditions of North America, is a serious question. If they pit fuel against food, with the result that prices rise and poor people lose access to the necessities of survival, we face critical decisions.

Competent observers forecast a worrisome burden on the land and water resources, not only of the United States, but of all the world.[1] On the other hand, some construct a rosier view of the future; one that sees little, if anything, but opportunities in the coming years.[2] With no reliable crystal ball, the most prudent course seems to be one that prepares for a difficult and demanding situation. If that future turns out to be better than expected, and our public policies and private actions turn out, in retrospect, to have been too prudent, the worst that can be said is that some economic opportunity may have been missed.

On the other hand, policies that proceed today as though there were no potential problems in the future lead us on a very risky course. If wrong, they could strand us on technological paths that lead nowhere; cut future options by prolonging waste and delaying needed conservation efforts; and necessitate harsh governmental intervention in place of gentler strategies that could have been pursued if started soon enough.

We need to look at new energy proposals, the technologies they entail, and the sources of fuel they would utilize, in terms of their total potential effect on the land. We cannot talk about gasohol as if it were the only strategy being considered; neither can we focus our attention on surface-mined coal. A new energy era is liable to see some of each, along with many other strategies as well. It is important that we try to see the situation whole, and deduce what that may mean.

In so doing, it is important to avoid the trap of constructing scenarios that bespeak impending disaster, but bear no more scientific credibility than those that forecast sunshine and roses. Forecasts must be couched in humble terms, particularly those that pretend to guess how the vast and complex market system in the United States will use and manage land and water resources in response to any given set of circumstances.

The indications for future pressures on the land are troubling, and call for immediate policy attention. But the straight-line projections of current trends will not continue. The reason is simple. They cannot continue. The courses we are on today, in terms of energy use, land use, land management, and water use, are simply untenable in the future. And the future is not very far away. But that should not be interpreted to mean that we will "run out of land". We will not. What appears more likely is a period of intense and difficult competition for land and water resources. The economic, environmental and social adjustments that will be required will be both significant and, for many, traumatic. The question, for both public and private decisionmaking, is "how will we prepare to make these adjustments with the least possible pain."

If we do not face that question, and face it soon, we will lose a great deal of land, in both quantitative and qualitative terms. Once that land is lost, it will not be easily reclaimed, if it can be reclaimed at all. We will forego options in soil and water conservation, and in energy technology, that will not be open again. Most significantly, we will risk losing a measure of personal freedom from governmental intervention in matters of land use and conservation.

The Land available for Agricultural Production

In order to evaluate the current and possible future trends in agricultural land availability, we start with the concept of a "resource pool". From the standpoint of cropland, that pool consists of the following elements, as estimated by the National Resource Inventories (NRI) carried out by the Soil Conservation Service (SCS) in 1977:[3]

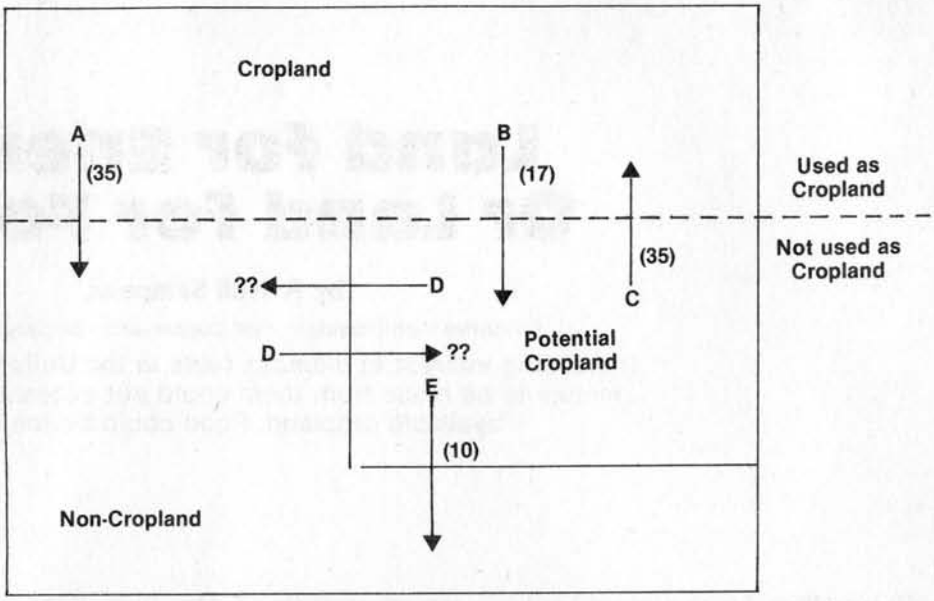
Cropland planted	343 million acres
Cropland slack	70 million acres
Total Cropland	413 million acres
High and Medium Potential Cropland	127 million acres
1977 Cropland Resource Pool	540 million acres

Two factors must be recognized about this resource pool. First, it is a fair measure of the amount of arable land in the nation as viewed in the economic and environmental context of 1977. As economic situations change, so will our view of the kinds of land we can afford to farm. Secondly, land use shifts are constantly affecting the arable land of the nation. Land is constantly being removed from the pool, sometimes permanently, and the size and nature of those shifts are a vital element in evaluating the agricultural productivity and future potential of the nation's land and water resources.

Figure 1 lays out a schematic design that may be useful. It illustrates how private land users shift land between cropland and the other types of use. The arrows indicate the direction land is shifted within the resource pool, and the numbers in parentheses give estimates of the amount of shift that was experienced between 1967 and 1977.[4]

Table 1 shows what may occur if these land use shifts continue into the future. In order to construct this table, some data adjustments were required. The 1975 Potential Cropland Study (PCS) estimated the acreage that had moved from one use to another between 1967 and 1975.[5] At the same time, it recorded the capability of the land and the potential for its future cropland use. The 1977 NRI measured the total amount of land in each use, but did

Figure 1



Elements of land use change that affect the land in the United States cropland resource pool, with estimates of the 1967-1977 acreage change (in millions of acres).

Table 1

Estimates of land use shifts within the cropland resource pool, by decades, assuming a continuation of 1966-77 trends.

	Type of Shift	1967 -1977	1977 -1990	1990 -2000	2000 -2030	1977 -2030 Total
		(millions of acres)				
A	Cropland to Non-Cropland	35	45	35	105	185
B	Cropland to Potential Cropland	17	22	17	51	90(a)
C	Potential Cropland to Cropland	34	44	34	102	180(a)
D	Potential Cropland to Non-Cropland	?				?
D	Non-Cropland to Potential Cropland	?				?
E	Potential Cropland to Non-Crop Uses	10	13	10	30	53
	Total Loss from Cropland Pool	45	58	45	135	238

(a) These estimates cannot be used to calculate the size of the cropland resource pool, as they indicate the shift of marginal cropland in and out of crop use. The same acre may be shifted 2-3 times in 50 years.

Table 2

Estimates of land use shifts within the cropland resource pool, by decades, assuming a slow-down of land use conversion trends in the future.

	Type of Shift	1967 -1977	1977 -1990	1990 -2000	2000 -2030	1977 -2030 Total
		(millions of acres)				
A	Cropland to Non-Cropland	35	45	20	17	82
B	Cropland to Potential Cropland	17	22	9	8	39(a)
C	Potential Cropland to Cropland	34	44	34	102	180(a)
D	Potential Cropland to Non-Cropland	?				
D	Non-Cropland to Potential Cropland	?				
E	Potential Cropland to Non-Crop Uses	10	13	5	4	22
	Total Loss from Cropland Resource Pool	45	58	23	20	104

(a) See footnote, Table 1

not identify which type of land had changed in use since 1967.[6] Thus, while both surveys could be used to estimate the *net* shift in use over a period of years, they must be combined in order to determine the internal characteristics of the changes in the cropland resource pool.

The size of the cropland resource pool under this set of projections would be 437 million acres in 2000 and 302 million acres in 2030. Shrinkage at such rates would, of course, result in a serious problem, in view of the estimates by USDA as to the cropland needs in the future. One major unknown lies in the set of shifts labelled as "D" in Figure 1 and Table 1. Land that was "potential cropland" under 1977 prices and conditions may not be so feasible in 1985. Or, conversely, it could be more feasible. A great deal of land outside the cropland resource pool is arable, given enough economic incentive and technological skill. For now, however, the 1977 estimate is the most logical to utilize. In the future, if conditions have changed, we can adjust our estimate of the size of the cropland resource pool.

Changing the Assumptions about Future Trends

Projecting the rate of land use change being experienced today into the future—especially for 50 years—is a very uncertain exercise, particularly when it appears logical that economic competition will force a slowdown in cropland conversion. This could be caused by many factors; most likely, however would be a rise in farm prices relative to other aspects of the economy. Should such a price rise occur, it would dampen agricultural land conversions.

Another possibility would be effective action at the local, state and national levels to protect farmland from conversion to other uses. Although there is no indication today that such action is immediately forthcoming, the resource competition forecast by the current studies may hasten action.

Table 2 is based on the following assumptions: (a) the rate of cropland loss experienced in 1967-77 will remain essentially the same through the decade of the 1980's, and (b) at that point, rising pressures will dampen the rate of change so that each decade to follow will see only one-half of the conversion experienced in the previous decade. Such an assumption would mean that the current loss of cropland to non-crop uses would be essentially halted by 2030.

These assumptions give a more sanguine picture of the land that might be available for cropping in the future, indicating that the resource pool might be in the range of 458 million acres in 2000 and 436 million acres in 2030.

Brewer and Boxley point out that the current rate of conversion of rural land to urban, built-up, rural transportation and water is about 2.9 million acres annually, up substantially from the trends observed in the 1958-67 period. Not all this conversion comes from cropland, of course. They estimate, in the 1967-77 period, about 700,000 acres per year of cropland were converted into these uses.[7] A portion of the remaining 2.2 million acres per year comes from pasture, range, woodland and other lands that also have a high and medium potential for conversion to cropland. To the extent that such land is lost to farmers, the nation has suffered a loss from its total cropland resource pool. Just how to evaluate that loss, and reconcile it with the estimates developed by Tables 1 and 2, has been the focus of concentrated study in USDA.

The estimate published in the Resource Conservation Act draft documents was for a loss from the cropland resource pool of 48 million acres over the next 50 years, but that figure had demonstrable deficiencies that were quickly pointed out by many analysts.

The Land Needed for Food and Fibre Production

In carrying out the Appraisal called for under the Resources Conservation Act, the USDA utilized a computer model developed in cooperation with Iowa State University. The model provides estimates of the amount of acres needed to produce the nation's major crops, on the basis of the least-cost methods and lands available. Commodity needs for the future were projected on the basis of predicted population, per capita disposable income, and export levels. When the number of bushels or tons of the basic commodity needs was known, the model provided estimates of the number of crop acres needed for production.[8]

There are two ways of gaining the crop production we will need in the future: increasing the acres of land cropped and increasing the yields per acre. Since the amount of land that can be cropped is dampened by rising costs of conversion as we move toward more marginal lands, the amount by which yields can be increased is a critical factor. There is some difference of opinion today as to the prospect for future yield increases. Many observers feel that, while yields will continue to increase, the rate will be much slower than in the past few decades.[9] Reasons given include uncertain climate, the continuing effects of soil erosion and other forms of land degradation, rising air pollution, and the continued prospect of increased prices for fertilizer, pesticides, and irrigation water—all of which have been instrumental in past yield increases. In explaining its forecasts of future yield, USDA pointed out:

> Over the past 50 years, agricultural productivity has grown at the rate of 1.6 per cent per year. The increase in productivity was about 2.1 per cent annually between 1939 and 1965, but the rate of growth has recently declined to about 1.7 per cent annually. Lu and Quance (1979) predict that without significant technological breakthroughs, the rate of growth in productivity will continue to decline. The agricultural productivity growth curve under the "science power" era is now entering the stages of declining growth rates.[10]

Pierre Crosson of Resources for the Future agrees with this assessment, saying,

> "My reading of the evidence indicates that since 1972 the trend in yields did in fact diminish relative to the pre-1972 period. Given the projected increase in real prices of yield-increasing inputs, the implication is that the slower rate of increase in yields experienced since 1972 will continue."[11]

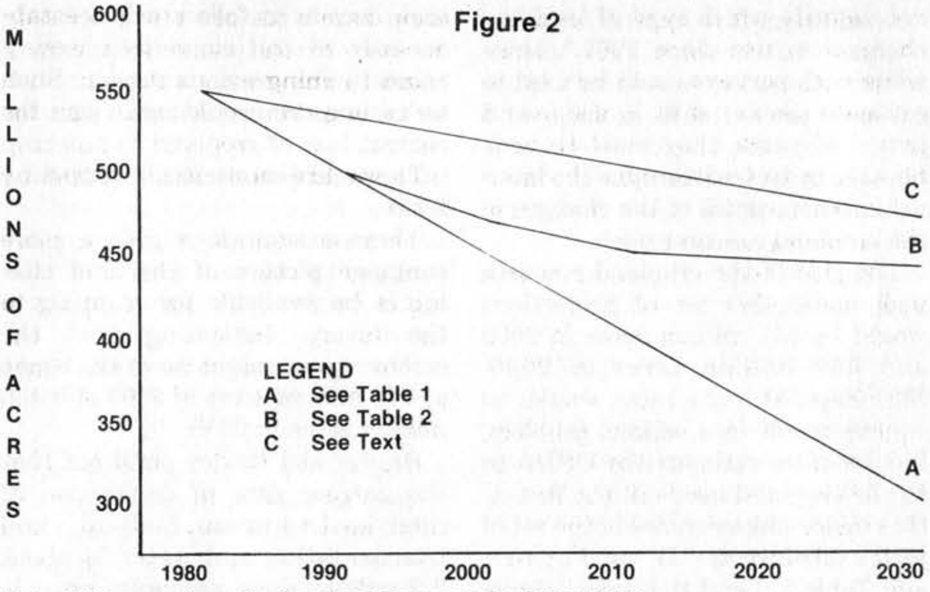
On that basis, the USDA-CARD linear programming model has recently been run to estimate the effects that three reasonably expectable rates of technology (and yield increase) might have on future land needs. The three levels tested were 0.6, 1.0 and 1.6 per cent per year. The results are shown in Figure 3. By the year 2030, the difference in acres planted under the three assumptions would be about 119 million acres, or almost 30 per cent of the average acreage forecast. That is, if nothing else, a fair measure of the nation's current reliance on a "technical fix". If we get it, our productive capability looks strong in relationship to foreseeable demands. If not, serious problems are imminent.

Adding Energy Issues to the Land Demand Equation

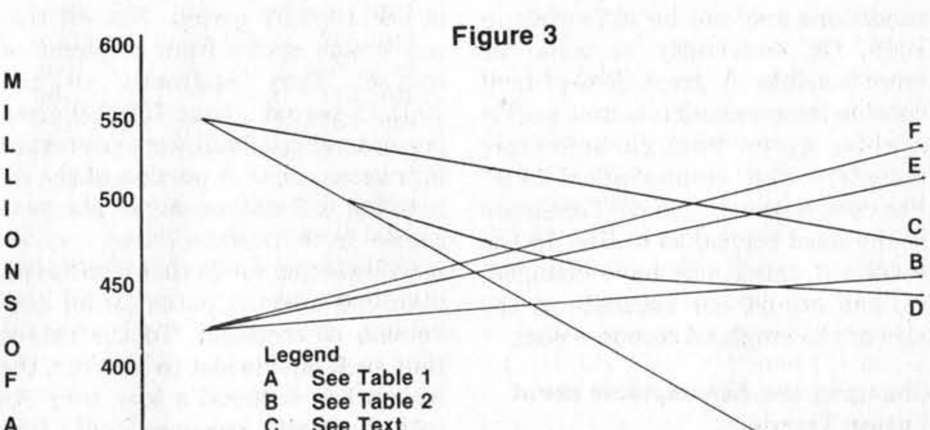
From the foregoing assessment, it is clear that future pressures on the cropland base could be fairly severe, even without added competition created by the energy situation. But, at the same time, there *will* be some new pressures created by the rising prices of petroleum-based energy, and it is important that we have some idea what those might be.

Because of the methods used to evaluate future farmland conversions in this paper, all of the energy-related pressures cannot be treated as new demands on the land. For instance, the demand for cropland as a result of surface mining, electrical generation, and competition for water are not "new". They have been part of the past conversion trends, and make up much of the pressure that would cause a continuation of those trends. Whether these kinds of land conversions will increase in the future or not is open to speculation.

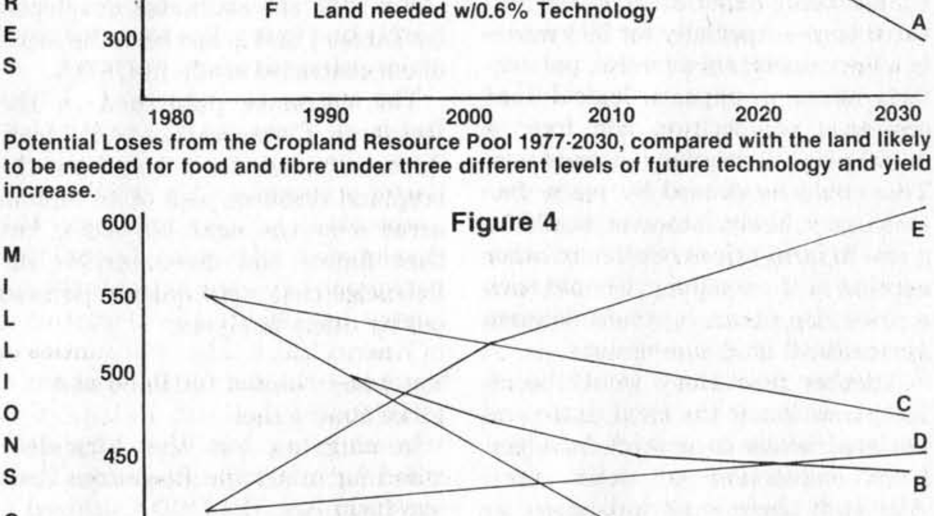
New demands will, however, be felt if large-scale production of biomass for energy is initiated. One of the most important could be the production of fuel ethanol as a means of stretching or replacing gasoline and diesel supplies. Another, less well recognized demand could come from the production of agricultural crops to be used as industrial feedstocks. Those types of agricultural production have not been a factor in the past, and thus will become important new additions to the previous trends.



Potential Losses from the Cropland Resource Pool 1977-2030



Potential Loses from the Cropland Resource Pool 1977-2030, compared with the land likely to be needed for food and fibre under three different levels of future technology and yield increase.



Potential Losses from the Cropland Resource Pool 1977-2030, compared with the land likely to be needed for food, fibre and industrial crop production under two different levels of future technology and yield increase.

In addition, it is instructive to remember that there will be energy conservation issues as well. If increasing prices of farm fuels and other inputs (largely fertilizer) cause farmers to shift toward a more land-extensive type of farming pattern, future acreage demands could be still higher than predicted in the preceding section.[12]

Mineral Extraction, Transportation and Processing

Surface mining, largely for coal, has taken an increasing amount of agricultural land in recent years. It was estimated that 3.2 million acres had been disturbed by surface mining for all minerals in the United States prior to 1965. Since that time, disturbed land has increased to 4.0 million acres in 1972, 4.4 million acres in 1974, and 5.7 million acres in 1977.[13]

The Soil Conservation Service estimates that the current rate of land disturbance due to surface mining now averages about 400,000 acres per year.[14] About half of this land is cropland, and this is a particular concern in states such as Illinois, where over half of the acreage in the strip mining permits issued between 1972 and 1977 was former cropland.[15] Much of this land is prime farmland as well, particularly in the west central and northern parts of Illinois.[16]

Cropland used for surface mining for coal is, theoretically, to be restored to its former productivity upon the completion of the mining process, under the terms of the Surface Mining Control and Reclamation Act of 1977. This Act contains strong language requiring the restoration of prime farmlands, in particular. But there is still some skepticism as to the ability to restore the land to its *former productivity*. J. Dixon Esseks points out that some soil scientists in Illinois have cautioned that reclaimed land "tends to suffer from inferior soil structure and excessive compaction", which may permanently impair productivity.[17]

In addition, surface mining for phosphates in Florida, North Carolina and Idaho; oil shale in Colorado; and uranium in several states will add to the toll. With these minerals, surface mine reclamation standards are not yet established by federal law, so the question of post-mining agricultural productivity is more problematic than for coal.

There are additional problems created for agriculture in a surface mine area, and not all of them are confined to the land where the mining is carried out. Again, to quote Esseks:

> The potential damaging impacts on agriculture from strip mining include the excavation of farmland under which coal lies (as far down as 75 to 100 feet) and the bulldozing and/or filling of half again as many acres for haul roads, storage areas, and other mining purposes. Stripping may also disrupt drainage on adjoining land, and it can pollute surface or ground water used by livestock and farm families. In the mid-1970's, coal surface mines produced an estimated 6,000 tons of sulphuric acid daily, which found its way into about 13,000 miles of streams.[18]

While there are many factors that may affect the rate of future surface mining, coal companies currently plan to mine another 312,000 acres between now and 1985. This would require an additional 120,000 acres to provide for storage areas, haul roads, etc. Of this acreage, approximately one-fourth lies in states with major prime farmland regions.[19]

The conversion of coal to liquid fuel is also one of the aspects that must be considered. President Carter proposed an Energy Security Corporation, which would foster the development of a 1 to 1.5 million-barrel-per-day synthetic fuels industry by 1990.[20] The Department of Energy has located 41 counties in 8 states—including 10 in Montana, 8 in Illinois, 7 in North Dakota, 6 in Wyoming, and 5 in West Virginia—that might be logical locations for a syn-fuel plant.[21]

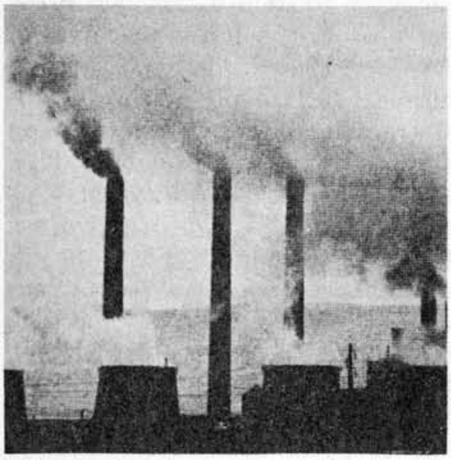
But, as Wendell Fletcher has pointed out, the DOE analysis explicitly excluded consideration of prime agricultural lands, problems with water transfers, and the "cumulative impacts of large scale facilities"—all crucial factors for assessing the impacts that such a programme migh have on agriculture and agricultural land.[22]

Thus, in terms of direct acreage impact, surface mining for coal will probably disturb somewhere in the range of 100,000 to 250,000 acres per year in the foreseeable future. Added to that will be the impact of non-coal surface mining and the off-site problems that can accompany surface mining operations. This acreage, particularly if much of it can be returned to productive use following the mining operation, will not, in itself, impose a serious burden on agricultural land at the national level. At the local level, however, serious dislocations seem likely. One study pointed out that "as of 1976, 202,422 acres in 40 Illinois counties have been affected by surface and deep mining."[23]

Acid Precipitation

It is not always easily or well recognized, but the pressures on agricultural land, and agricultural productivity, can come from across the fence. A case in point is acid precipitation stemming from air pollution, largely the result of both the form and amount of fossil fuel energy being utilized. Acid precipitation is beginning to affect crop production and forest yields, although the extent of the nationwide damage is not yet known with any accuracy.[24] A recent increase in the acidity of rain and snowfall, particularly in the Northeast, has now spread so that it extends from Illinois eastward.[25] While the effect on crop yields, and therefore, on the amount of land that must be added to the cropland inventory to offset lost production, is not known, there have been estimates that it may be as high as 1 per cent.[26] This would be roughly equivalent to the annual loss of production from 3.5 million acres.

That acid rain is a serious problem is not in question; that it will grow more serious is equally certain. A recently published Department of Energy report estimates that sulphur dioxide emissions from coal-fired utility boilers could increase by 15 per cent by 1990 even if Federal Clean Air Act requirements are maintained. The effects of coal conversion by other industries could result in an increase of 149 per cent when 1990 is compared to 1975.[27] If efforts to relax the emission standards under the Clean Air Act are successful, the impacts of acid rain will, of course, rise accordingly.



Acid rains from the burning of fossil fuels causes agriculture yields to drop.

Electrical Generation and Transmission

No small amount of land is used in the generation and transmission of electricity, and forecasts for the future circulated by the electric power industry suggest that additional demands will be significant, as well. In 1978, with existing generating capacity somewhere in the range of 579,000 MW, the industry projected that some 308,000 MW of added capacity would be in operation by 1987.[28] Power plants, whether coal or nuclear, need land: 2000 acres or more is common. One nuclear plant in the Chicago area took 4,480 acres, most of which had once been farmland.[29]

In estimating the amount of land liable to be required in the future, Fletcher uses the figure "well over 100,000 acres" before 1987, while Esseks estimates that "New coal and nuclear power plants may result in the permanent conversion of yet another 1.5 million to 2 million acres."[30]

Although it is difficult to compare their land requirements with those of other types of power generating facilities, hydroelectric power plants are also important land users. Reservoir sizes of 1,000 to 25,000 acres are common, and much of this land is valley bottomland that will qualify as prime farmland. But hydroelectric reservoirs also serve a variety of other purposes, such as flood control, irrigation and recreation, so they are difficult to compare with other forms of electrical generation facilities. In addition, the hydro plant contains its own "fuel" source within the acreage taken for the reservoir. This is in contrast to a coal-fired plant that might only take 2,000 acres of land, but require thousands of acres to be strip-mined to provide fuel over the life of the facility.

In addition, we have about 4 million acres dedicated to rights of way for transmission, with the estimates of future needs ranging from 1.5 million to 3 million additional acres before the year 2000.[31]

The important aspect of these estimates does not lie in the acreage within the transmission line rights-of-way. That acreage is part of the loss that we would expect if current trends continue (see Figure 2). The issues that may prove to be most difficult are those concerning the effect of new extra-high-voltage transmission lines on surrounding land use, crops, livestock and human health. Research on this problem in the United States has been sketchy, at best, but enough controversy has been generated to suggest that agricultural users next to transmission lines may soon face restrictions in the use of extra-high-voltage rights-of-way.[32] Even without these kinds of problems, farmers face disruptions and added costs in their operations where power line structures are placed in fields.[33]

New Competition for Agricultural Water

Water is an ordinary, yet amazing compound. It covers nearly three-fourths of the earth's surface, but less than 3 per cent of that total is fresh water. Oceans, ice caps and glaciers contain some 99.35 per cent of the world's 326 million cubic miles of water. It is from the remaining ⅔ of 1 per cent that man finds the usable fresh water to supply his needs.[34]

More water is used for agriculture than for any other use. Almost half of the fresh water withdrawn from surface or ground water supplies is for irrigation, and over 80 per cent of the water that is consumed in the nation (that is, not returned to streams or ground water reservoirs) is consumed in this manner.[35] But agriculture's grip on the nation's water supply is largely in terms of law and tradition, not economics. As Don Paarlberg notes, "Compared with its rivals, agriculture is not an efficient user of water." Nonfarm users such as municipalities, mining interests (especially coal, potentially oil shale), industrial users and developers have the advantage in that "economics is on their side in overwhelming measure."[36]

Of the nation's cropland in 1977, about 14 per cent was irrigated, up from some 8 per cent in 1958.[37] Every state but Rhode Island and New Hampshire reported some irrigation in 1977, but the major acreage occurs in the 17 western states. There, the competition for water is fierce, and the impacts of increased energy production promise to make it still more difficult. The USDA predicts that "the areas where there will be great concern over water used for energy will be in the Missouri, Ohio, and Upper Colorado regions where there are large coal and oil shale deposits."[38]

The Colorado already serves 15 million people, with considerable conflict in regard to both quantity and quality of the available water, and because it is one of the largest storehouses of energy resources in the U.S.—including coal, oil, natural gas, uranium, tar sands and oil shale deposits, new development means serious water disputes between farmers and energy producers.[39]

To make matters worse, the available supply of water is shrinking most rapidly in some of the same areas where new energy-related uses will be most demanding. The most serious areas of ground water overdraft and declining water tables are southern Nebraska, western Kansas, western Oklahoma, western Texas, eastern New Mexico, eastern Colorado, central Arizona, and the San Joaquin Valley of California.[40]

In the Texas High Plains, the annual overdraft from the Ogallala Formation is 14 million acre-feet.[41] As natural gas prices have gone up, more and more irrigation has been discontinued, put out of business by the rising cost of energy and the increasing work needed to lift water from the declining water table. Net farm income in the region is expected to fall 40 per cent by the year 2000 as 3.5 million irrigated acres revert to dryland.[42]

Because of the existence of similar problems throughout much of the region, a High Plains Aquifer Study is being conducted by the U.S. Department of Commerce, in cooperation with the High Plains Council. This look at both the economic and social impacts of declining water supplies in the region should map out the terrain for what seems certain to be a difficult battle for available water.[43]

In that battle, the outcome is virtually pre-ordained. Again, to quote Paarlberg:

> "That water use in the West will be a major public policy issue in the decade ahead is a certainty. And that agriculture will lose relative to nonfarm users also seems certain. . . . Only if agriculture is willing to accept some modification of tradition and received doctrine, or if the West settles for no growth, can collision be avoided. And if collision does come it seems likely to me that agriculture will be the loser."[44]

So far, we have evaluated the agricultural land situation and the resulting conflicts that may ensue as a result of energy issues largely in terms of the continuation of past trends and technologies. Surface mining, electrical generation, coal gasification, oil shale production, coal slurry pipelines, and many other competitors for agricultural land and water may be the result of new energy technologies or economic conditions. But that type of competition for the land is much the same as has been experienced in the United States over the past two decades. In large measure, it is already factored into our assessment of the future of agricultural land, insofar as we base that assessment on the continuation of current trends.

But there are new factors that are not a continuation of the past, and therein lies the basis for a new urgency in the energy/food issue.

Biomass as a Fuel Source

Burning biomass from current plant stocks (as opposed to burning the fossilized remains of prehistoric plants) is one way to replace the energy provided by burning increasingly expensive petroleum supplies. Generation of industrial power by woodburning is nothing new, of course. It was a feature of many early energy attempts, such as the woodburning locomotive that carried its own wood supply, or the sawmill that burned waste products to generate steam to run the mill. Now, with prices of other fuel sources going up, wood has been re-discovered.

But what has happened to date may be dwarfed by what could happen in the future. The Energy Security Act of 1980 contains 1.45 billion dollars through FY 1982 for financial assistance to synthetic fuel projects using biomass energy sources.[45] The increase in biomass production likely to result will be a new pressure on the land. Many woody plants can be grown on land that is not high quality cropland, and such biomass production will not compete immediately with food production. Using this land for biomass production, however, may preclude its use for crops in the future.

A great deal of added pressure could fall on the current cropland base, however, if plans for utilizing crop residues as an energy source are not carefully implemented. Larson, et. al.[46] estimated that the nine leading crops produce about 363 million metric tons of residues yearly. If all this were burned for energy, it would provide about 5 per cent of the nation's energy use. But such a removal would lead to disastrous soil erosion levels, and thus cannot be seriously considered. What can be considered, however, according to Larson and Pierce, is the use of from 10 to 80 per cent of the residues, depending on crop, location and soil type.[47]

This calculation was based solely on the value of the residues in preventing soil erosion, and did not account for the value of the residues in providing plant nutrients or contributing to soil tilth and structure. Also not considered was the importance of plant residues as a primary source of energy for soil microbial activity, a value that might best be assessed by conducting an energy analysis of the soil system.[48] At this point, soil scientists do not agree on the amount of crop residues that can be safely removed without adverse effects on soil productivity.[49] The most prudent course appears, clearly, not to depend on them too greatly.

Currently, it is estimated that biomass energy provides less than 1.5 per cent of the nation's total energy consumption, with some forecasters predicting that this amount could be tripled by the end of the century and doubled again by 2020.[50]

Judging the land effects of such an increase in biomass energy utilization is not a simple matter. In addition to questions about the type of biomass to be used, and the manner and locations in which it is to be grown, lies a significant question of technology. If small-scale biomass technology is used, where the energy is produced largely for on-farm or home use, the implications for the land will be far less threatening than if biomass energy is produced on large-scale, commercial operations.

Small-scale uses have risen rapidly in recent years. For example, the number of wood-burning stoves has been estimated to have increased from 1 million in 1974 to 5 million in 1976.[51] Farmers are lining up by the hundreds for non-commercial fuel alcohol permits at the U.S. Bureau of Alcohol, Tobacco and Firearms. Fletcher points out that "At the end of 1978, there were only 18 such permits in effect. By October, 1979, over 700 permits had been issued, and 3000 applications—most of them from farmers—had been received."[52]

Since the energy demands of American farm production are only about two per cent of total national consumption, farmers may find it both possible and advantageous to develop additional on-farm sources of liquid fuel. Even though several

Soil erosion would increase disasterously if all crop residues were taken from the land and made into biomass fuels.

studies have shown that the economics of such production are marginal at best, farmers may feel that the advantages of being somewhat more energy self-sufficient on the farm make the exercise worthwhile.[53] If combined into a crop rotation that includes ample soil-building crops and appropriate use of crop residues, the implications of such a strategy on the land seem minor.[54]

Even so, some critics point out, agriculture could not hope to become fully self-sufficient in fuel production without some major readjustments. Jackson, et. al. calculate that, in order to produce the gasoline and diesel needed to run America's farms, 133 million acres of corn would need to be devoted to alcohol production.[55] This estimate, which appears to be based on the *net* energy that can be produced from an acre of corn, without accounting for the energy benefit in the distillers grain by-product, is substantially higher than the estimates of the amount of land that would be required simply to produce the feedstock for the alcohol fuel process.[56]

Going further, the notion of growing crops to provide fuels for large-scale commercial strategy makes the numbers sound even larger. USDA has estimated that it would take about 300 million acres of corn to produce just 10 per cent of the nation's current energy usage.[57] This is about triple the acreage currently in corn production, and 75 per cent of the total cropland in use in the nation today. Such a production level from cropland is clearly impossible, simply on the basis of land constraints. Whether there are offsetting methods of production that could be used to lower those land needs is still a matter of some contention.

In addition to cropland, there are about 740 million acres of forest land in the nation, part of which could be devoted to the production of biomass for energy. In its Resources Planning Act report, the Forest Service estimated that some 488 million acres of this land are capable of commercial timber production. The current inventory is estimated at 800 billion cubic feet, not counting the tops, limbs, bark and other portions not usable in ordinary wood products production.[58]

Wood products can be used for energy by direct burning, through the production of methanol, or through "gasification". Most biomass-derived energy is currently obtained by direct burning, but the development of improved technology for converting cellulosic materials into alcohol seems likely. Many experts feel this will be the source of the majority of the biomass used for energy, at least in the near future. Crosson notes that "At a meeting of the Bio-Energy World Congress and Exposition, held in Atlanta in April, 1980, most speakers agreed wood rather than grain is the most economical source of biomass for energy production."[59]

This forecast portends greater pressure on forest lands, pressure which will add to the needs created by the growing demand for wood products in building and fibre uses as well as the pressure for conversion of some forest lands to cropland. One estimate is that 70 to 83 million acres of forest plantations would be required to produce just 10 per cent of the nation's 1980 energy use.[60]

Gasohol: Panacea or Problem?

Among the major elements of the debate surrounding a national gasohol programme have been questions of competition between food and fuel and the issue of whether a net positive energy balance can be achieved if the energy consumed in crop production is included in the calculation.

If a net liquid fuel balance is realized, gasohol may be said to have converted a type of energy (sun) that is not scarce to a type (gas or diesel) that is. The Department of Energy estimates that new distilleries (designed especially to produce fuel-grade alcohol) could result in a positive liquid fuel ratio approaching 4:1.[61] The food versus fuel debate is less settled and less likely to be resolved through technology. That the distillers grain left over after the fermentation process contains all the original protein of the grain and can be used as a livestock feed, does not, in itself, resolve the question.

Lester Brown points out that there may be a limit to the amount of distillers grain that can be used as a feedstuff. Producing 2 billion gallons of ethanol from corn would yield 17 times as much distillers grain as was consumed in 1976.[62] In light of the fact that distillers grain is a less desirable feed supplement than soybean meal, it is doubtful that this much can be absorbed by the current animal industry.[63] The net effect on food supplies that will result from shifting cattle from soybean meal to distillers grain, and soybean land to corn for ethanol is not subject to a simple calculation, even if the shift is technically feasible.

In Brazil alcohol from biomass residues is making up a significant proportion of automobile fuel.

Another element of the debate concerning a national gasohol programme that has received less attention is its likely impact on the land base. If marginal lands are brought into production as a result of new demands and higher prices for farm crops, added soil erosion problems are certain. The National Association of Conservation Districts expressed concern about this problem in testimony before the House Agriculture Committee in 1979.[64]

The Office of Technology Assessment has also expressed concern about the implications of a national gasohol programme on land and food:

> A commitment to produce enough gasohol to supply most U.S. automotive requirements could involve putting approximately 30-70 million additional acres into intensive crop pro-

duction. Assuming the acreage was actually available, this new crop production would accelerate erosion and sedimentation, increase pesticide and fertilizer use, replace unmanaged with managed ecosystems, and aggravate other environmental damages associated with American agriculture.

A combination of ethanol subsidies and rising crude oil prices could drive up the price of farm commodities and ultimately the price of food. The extent to which this will happen depends critically upon how much additional cropland can be brought into production in response to rising food prices and, eventually, on the cost of producing ethanol from cellulosic feedstocks. These and other major uncertainties, such as future weather and crop yields, make it impossible to predict the full economic impact of a large fuel ethanol programme.[65]

Even the Department of Energy, trying to demonstrate both the viability of and the need for a national programme to encourage ethanol production, could not refrain from noting that major problems might be created for both agriculture and the land.

> From our analysis, it appears that an upper limit of approximately 4.7 billion gallons per year of ethanol could be produced from raw material supplies using existing technologies, if conversion capacity capable of processing these feedstocks existed. This limit could be achieved by bringing into production all existing grain land and by supplementing food processing wastes with sugar surpluses and fermentable municipal solid waste. Achieving this limit would be expensive, and would reduce the flexibility of U.S. agricultural land and restrict options for food production.[66]

Wes Jackson brings the problem down to a more human dimension, arguing that the issue is primarily one of ethics:

> Keep in mind that the energy in the alcohol required to meet the demands of an average U.S. car for one year could alternately be used as food to feed 23.5 people for an entire year. From our point of view, the issue is not whether the alcohol is there, but that massive alcohol production from our farms is an immoral use of our soils since it rapidly promotes their wasting away. *We must save these soils for an oil-less future.*[67]

Prior to 1979, the Department of Agriculture expressed serious reservations about the impact of a national gasohol programme, and the ability of the land to absorb the added demand. Since then, however, the Department's position has become more favourably disposed toward the production of gasohol. In describing the Department's new programme to Congress, Deputy Secretary Jim Williams noted:

> "This alcohol fuels programme represents a basic policy change. The USDA is now including production of farm commodities for alcohol feedstocks as a major objective of agricultural policy—alongside the production of food, feed, and fibre. Grain reserve targets, commodity price supports, acreage diversion and other related agricultural policies are being managed to include the grain requirements for alcohol equally with other consumers of grain."[68]

In January, 1980, President Carter set a national goal of producing 500 million gallons of ethanol by the end of 1981. At USDA, Secretary Bergland has estimated that the goal could be reached by a 4 per cent increase in the land devoted to corn (or a 4 per cent increase in average national corn yields), and noted that "Distillation capacity, not agricultural feedstocks, is currently the restraining factor on fuel alcohol production."[69]

Gasohol is clearly not a cost-free solution to our energy dilemma. Whether it is panacea or problem probably awaits an answer. One thing is certain—that answer is likely on its way. With the enthusiastic support of farm groups, who see a new market that might give farm prices a much-needed boost, and Congress, who have been looking for something (anything?) to make farmers happier, the passage of the Energy Security Act of 1980 signals a major political commitment to this effort.

That ethanol production is attractive to oil companies is in little doubt. In June, 1980, Martin Abel told an RFF Conference that:

> Only recently Ashland Oil and Publicker announced plans for a 60 million gallon plant at South Point, Ohio, and American Maize Products and Cities Service Corporation announced a 50 mil. gal. plant at Hammond, Indiana. Furthermore, an Iowa cooperative is considering building a 50 mil. gal. plant. We believe, therefore, that beginning in 1982, production capacity will rise rapidly, reaching 1.1-1.3 bil. gal. by 1985-86 and 1.5-2.0 bil. gal. by 1990-91. Thus, if U.S. and world energy prices evolve in the way we and others anticipate, there may be no shortage of incentives for investment in facilities to produce ethanol from grain.[70]

If Abel is correct in his assessment for the future, and USDA was correct when they predicted that such major investments in plant capacity would tend to lock the nation into the allocation of grain for fuel production up to plant capacity once conversion plants are constructed and operational, it seems that the die is cast.[71] The challenge for conservationists will be to help farmers and ranchers find ways to integrate energy production into their land and water management systems in such a way that we do not permanently damage our basic resources in the experiment.

Industrial Feedstocks from the Land

In addition to the petrochemicals that are imported to provide a wide range of industrial feedstocks, the United States also imports a wide variety of agricultural materials. Included in the list are natural rubber, waxes, resins, newsprint and adhesives. Many of these materials can be produced within the country, and this is an option that is beginning to look more and more attractive to policymakers. Economically, the stakes are large. The U.S. currently imports agriculturally-produced industrial materials at the rate of an estimated 27.3 billion dollars per year. In addition, another 8 billion dollars is spent for petroleum products to be used as industrial feedstocks. (See Table 3)

Recent political instability in many of the countries where this material is obtained have caused a rising interest in the potential for domestic agricultural production.

Interest in the Congress, the Department of Defence and the industrial community has been centred on the possibility of achieving more self-reliance, at least in those products that are felt to be either "strategic" (critical to defence) or "essential" (required by industry to continue normal operations).

In assessing the situation, Howard Tankersley, Director of Land Use for the Soil Conservation Service, says:

> Sufficient technological research has been done that we could commercialize the agricultural commodities that produce the substitutes for these imports within 5 to 20 years, if that were to become a national goal. However, achievement of total domestic production of these products would require the use of about 55 million acres of land. This acreage is equal to about 22 per cent of our current cropland base or about 17 per cent of our crop and pasture land base (SCS figures). While it is technologically possible to produce all these essential materials domestically, studies need to be undertaken to determine the optimum level of production to meet the objectives of this programme, given the constraints of our land base and foreign trade commitments.[72]

Not all the land for these new crops would need to come from the current cropland base. Jojoba, for example, is a desert shrub that can be grown in the southwestern deserts under conditions where little, if any, other agricultural production is possible. Jojoba seeds contain 45-60 per cent of an unsaturated liquid wax similar in composition to sperm whale oil.[73] Commercial production of Jojoba could not only make the nation more self-sufficient in a "strategic" material (sperm oil), but also reduce the demand for whales, which might help prevent their extinction.

Jojoba can be planted in hot, low deserts where freezing is not a hazard. With small catch basins around each plant to concentrate rainwater, it is possible to grow the crop with natural rainfall or limited supplemental irrigation. It takes five to seven years for the plants to mature and produce an economic yield, but a 60-year-old plant can produce up to 30 pounds of seed per year.[74]

Guayule is another desert shrub that is currently undergoing intensive research. It produces rubber of a quality nearly identical to that of the Hevea rubber tree, with the foliage containing up to 20 per cent rubber by weight.[75] Harvesting the entire plant is possible every two to five years, after which the plant will regenerate from its perennial rootstock. Nabhan reports yields of 200 to 1,000 pounds per year, with researchers testing varieties that will have better, more dependable yields.[76]

Two other crops, buffalo gourd and devil's claw, also show promise for semi-arid agriculture in the southwest. Buffalo gourd grows well on disturbed soils and can survive as little as ten inches of rain annually. It yields up to 3,000 pounds of seed per acre that contains over 1,000 pounds of vegetable oil and 1,000 pounds of protein meal. In addition, the roots can be harvested for starch, yielding up to 6-7 tons of starch per acre.[77] Devil's claw seeds contain up to 40 per cent oil and 27 per cent protein, with the oil similar to safflower. The plant is adapted to both dryland and irrigated farming, with work to collect and improve seed stocks now under way.[78]

These crops offer a potential cropping alternative to land that could not be cropped otherwise, and they also offer a possible agricultural future for land in the southwest that is now being threatened by loss of irrigation water. In addition, there are crops that could become competitors for agricultural land in the more humid climates. Among these are Crambe, an oilseed crop that contains 30-40 per cent oil, of which up to 60 per cent is erucic acid. According to Princen, Crambe oil "has been evaluated successfully for the manufacture of lubricants, plasticizers, nylon and other applications."[79]

Crambe has been successfully grown from North Dakota to Texas, and from California to Connecticutt, with yields of 600 to 4000 lbs. per acre. Typical yields run around 2000 lbs. per acre under normal management and conditions.[80] Agricultural researchers are fairly confident that the basic information needed to successfully grow Crambe is available. The crop is said to be competitive with all traditional crops except corn at a sales price of 8 cents per pound.

Kenaf is another crop that can compete for agricultural land, particularly in the warm, humid zone. It has produced yields of 5 to 10 tons of dry harvested matter per acre, about twice the production that can be obtained from normal tree farming operations.[81] As a source of cellulose for newsprint or other paper products, kenaf appears very promising.

Princen[82] has demonstrated in several papers that growing domestic crops to replace imported materials is, indeed, a feasible option. It is not, however, without its problems. One major problem is the need for coordination and timing of all facets of the research and development programme. When the knowledge is on hand for growing the crop, the industrial capacity to use it must also be ready. If one gets ahead of the other, there is a problem. With most of the crop research in USDA and most of the utilization research in industry, timing is made more difficult. In addition, American industry has always found it easier to buy imports than to deal with the necessary problems of domestic production. In this way, they have left "the worries of production, processing, and byproduct utilization to the countries of origin."[83] A domestic production strategy will make us address those problems directly, and some will not be easily resolved.

Regardless of the problems, the nation's interest in becoming more self-reliant in these products, in decreasing consumption of petroleum by an estimated 640,000 barrels per day, and in reducing our import bill by an estimated 37 billion dollars per year, is likely to lead to added research, testing and production. These new crops could, in the future, become an important part of the agricultural picture.

Estimating the Land Requirements of Industrial Crops

It is apparent that the "new" energy-related demands on land could result in a significant addition to the current agricultural land use situation. Gasohol, for example, could add from 8 to 30 million acres of effective demand in the next two decades if, as Martin Abel predicts, the new industrial capacity is built on the basis of using corn as the major feedstock.

The production of industrial feedstocks could add up to 55 million more acres of industrial crops, but it appears that well over half of those acres would come from lands not now in cropland or considered to be potential cropland for ordinary crops. Without a great deal of data to rely on, it might be reasonable to estimate that the new demand for cropland could be in the range of 10-20 million acres by the year 2000, with the remainder of the production coming from semi-arid or desert lands.

The low range estimate I would make of the total demand on U.S. cropland for industrial products by 2000 is 18 million acres. The high range would be of the order of 50 million. These would be acres in addition to those needed for food, feed and fibre production as we now know it, allowing for some substitution and double-usage such as a gasohol-cattle feed dual use or double cropping that involved an energy crop with a food crop.

These numbers are not, by themselves, very startling. It has been estimated that 50 million acres of idle cropland was brought back into production in response to the Russian grain purchase and the bad weather experienced in the period from 1972-74.[84] We have estimated that some 34 million acres of potential cropland were converted to cropland in the decade between 1967 and 1977 (Table 1). If we are willing to assume that the land is available, adding that many acres again in the next two decades, does not sound unreasonable.

What makes this added pressure sound ominous, however, is the concurrent need, shown by the RCA, to have from 407 to 520 million acres of cropland still available in 2030 to meet growing needs for food and fibre at home and abroad. Coupled with the demand for industrial crops, this adds up to a low estimate of 425 million acres needed and a high estimate of 570 million. Figure 4 shows how these demands might develop in the future.

Scenarios for the Future

Any forecast of future land use in the United States must necessarily be based on data that are, admittedly, inadequate. The best data at hand are being assembled by the USDA as part of the Resources Conservation Act study and by the National Agricultural Lands Study. Both studies are quick to point out the data deficiencies. Brewer and Boxley ascribe this, in part, to the fact that federal agency budget constraints have resulted in very different levels of statistical reliability in the various inventories that have been made in recent years.[85]

A more serious question to the forecaster, however, is how well these past trends can be used to predict future trends. In looking at current data relating to the use of agricultural lands, we face a quandary. The trends of the recent past cannot continue much longer; we are losing too much land, and too much topsoil to erosion, too rapidly. Logic dictates that these losses must slow down. The problem comes in looking for evidence that they are slowing down, or that political and/or economic forces are working that will slow down the loss of farmland productivity. As of right now, there appears to be none.

Thus, we are forced into the dichotomous position of saying that, although we believe that the past trends cannot be allowed to continue; it seems likely that they will, at least in the short term.

Figure 4 predicts a range of situations where economically disruptive competition for agricultural lands may fall between 1990 and the end of the century. Even the most optimistic forecasts predict resource shortages by 2020. Some of the most serious, and imminent, problems are those that are indicated by the short-term (less than a decade) continuation of the trends that appear to be happening *right now*. It is clear that immediate and serious policy attention needs to be paid to the cropland resources of the nation. The most optimistic case would still require the conversion of millions of acres of land into crops. That land is now in pasture, range or forest, and its conversion will both cost money and cause the loss of other values. Some new croplands may result in the draining of wetlands, and that adds another dimension of environmental loss and concern. If energy prices continue to climb, in real terms, the conversion of this land will cause the average costs of production to be somewhat higher.

Soil erosion will be accelerated by this shift, since cropland is more prone to erosion than the less intensive agricultural uses and the potential cropland is, on the whole, more erosion-prone than the land currently cropped. Recent experience indicates that not only does new land have higher soil erosion potential, but the high cost of conversion tends to discourage the added investment in soil conserving practices.[86]

The conservative case, of course, means far more competition for land, and far more intensive problems with conversion costs, soil erosion, environmental degradation, and supply management. It would require the re-discovery of many acres currently thought to be uneconomic to farm. Many of those acres will be in small, isolated tracts, and will require a different farming style than today's large machinery will allow. Maybe that would mean that small farms would once more be economic in some parts of the country, and many would count that as a positive, rather than negative, effect.

The important thing to remember about the crossing of the "supply" and "demand" lines in Figure 4 is that it will not happen. There is no such thing as a "negative acre". We will not run a deficit; we will simply not be able to produce some commodities for some markets. As a result, food prices will rise; but that is foreordained also, if energy prices continue to rise at a two per cent real rate each year. We are talking about the degree to which these effects will be felt.

The most critical factor is the almost total loss of flexibility to respond to normal fluctuations in climate. USDA has pointed out that concern in relation to the gasohol question, but the problem is acute whether we enter the gasohol market or not. As they note, "the volatility of farm production levels is *increased* by intensive agricultural practices. For example, heavy use of nitrogen fertilizer to increase corn yields has also increased the amplitude of fluctuations in corn yields due to weather variations, since positive yield response to nitrogen is dependent upon favourable weather conditions."[87]

The United States has used its tremendous land resource, its constantly growing technology, huge amounts of capital, and favourable weather conditions to build up an intensive, high-producing agricultural plant. With technology seeming, at the moment, to have reached a plateau; growing competition for available capital in all parts of the economy; and hints of less certain weather conditions; the attention turns to the land base. If the yield-increasing investments and technologies do not prove to be adequate on the existing, and shrinking, cropland base, is the land reservoir adequate to cope with all foreseeable demands? The answer, it appears, is "no, not any longer."

America needs a new strategy of wise land use, conservation management, and planned re-investment in the productive land base more than at any time in the Nation's history. Without those strategies, market forces are going to hasten the destruction of productive lands that will be sorely needed before the century draws to a close. Competition between industrial crops and food crops is going to increase, with the end result all but pre-ordained. Food costs are going to rise, and low-income people will suffer first and worst. The time spent in pointless arguments over whether agricultural land protection is needed in the national interest is a luxury the nation can no longer afford.[88]

References

1. Brown, Lester R. 1980. *Choosing food or fuel.* JSWC, Vol.35, No.3.
2. Kahn, Herman, William Brown and Leon Martel. 1976. *The next 200 years: A scenario for America and the world.* William Morrow & Co., New York.
3. Soil Conservation Service. 1979. *SCS national resource inventories, 1977: final estimates.* U.S. Department of Agriculture, Washington, D.C.
4. The concept of the "cropland resource pool" and the research needed to develop Figures 1-3 and Tables 1-2 were developed by the author and Allen Hidlebaugh, Senior Staff, Resource Inventory and Monitoring, National Agricultural Lands Study, for use in an unpublished paper presented to USDA by the NALS staff. (See note 5).
5. U.S. Department of Agriculture. 1977. *Potential cropland study.* Statistical Bulletin 578. Washington, D.C.
6. This was due to the fact that the 1977 NRI did not measure the same exact point as was measured in 1967, and compare 1977 use to 1967 use. The 1975 PSS did this, so is a valuable tool in understanding both the amount and characteristics of the land that is being shifted from one use to another by the nation's private land users.
7. Brewer, Michael and Robert Boxley. 1980. *The potential supply of cropland.* Paper presented at RFF Symposium on the Adequacy of Agricultural Land, Washington, D.C., June 19.
8. U.S. Department of Agriculture. 1980. *Appraisal 1980: Review draft, part II.* Washington, D.C.
9. Bertrand, Anson R. 1980. *Overdrawing the nation's research accounts.* JSWC, Vol.35, No.3.
10. USDA. 1980. *Op. Cit.*
11. Crosson, Pierre. 1979. *Agricultural land use: A technological and energy perspective.* In Max Schnepf (ed.) *Farmland, Food and the Future.* Soil Conservation Society of America, Ankeny, Iowa.
12. *Ibid.*
13. Soil Conservation Service. 1979. *Basic statistics; Status of land disturbed by surface mining in the United States, as of July 1, 1977.* U.S. Department of Agriculture, Washington, D.C.
14. Dideriksen, R.I., A.R. Hidlebaugh, and K.O. Schmude. 1979. *Trends in agricultural land use.* In Schnepf, *Op. Cit.*
15. Illinois Department of Mines and Minerals. 1978. *1977 annual coal, oil and gas report.* Cited by Esseks, *Nonurban competition for farmland.* In Schnepf, *Op. Cit.*
16. Esseks, J. Dixon. 1979. *Nonurban competition for farmland.* In Schnepf, *Op. Cit.*
17. *Ibid.*
18. *Ibid.*
19. Office of Surface Mining Reclamation and Enforcement. 1979. *Final environmental impact statement, section 501(b) regulations.* U.S. Department of the Interior, Washington, D.C.
20. Fletcher, W. Wendell. 1980. *Farmland and energy: A conflict in the making.* Unpublished manuscript submitted to the National Agricultural Lands Study. American Land Forum, Washington, D.C.
21. U.S. Department of Energy. 1979. *Environmental Analysis of Synthetic Liquid Fuels.* Cited by Fletcher, *Op. Cit.*
22. Fletcher, *Op. Cit.*
23. Smith, Janet M., David Ostendorf, and Mike Schechtman. 1978. *Who's mining the farm?* Illinois South Project, Herrin, IL.
24. U.S. House of Representatives. 1979. *Agricultural and environmental relationships: Issues and priorities.* Subcommittee on Natural Resources and Environment, Committee on Science and Technology and Subcommittee on Conservation and Credit, Committee on Agriculture. Washington, D.C.
25. U.S. Environmental Protection Agency. 1978. *Environmental effects of increased coal utilization: Ecological effects of gaseous emissions from coal combustion.* EPA-600/7-8-108. Washington, D.C.
26. U.S. House of Representatives. *Op. Cit.*
27. U.S. Department of Energy. 1979. *An assessment of the national consequences of increased coal utilization.* Washington, D.C.
28. U.S. Department of Energy. 1978. *Additions to Generating Capacity: 1978-1987* Washington, D.C.
29. Jacobsen, Sally. 1973. *Land use dispute in Illinois: Nuclear power vs. crops.* Bulletin of the Atomic Scientists 29. Cited by Esseks, *Op. Cit.*
30. Fletcher, *Op. Cit.* and Esseks, *Op. Cit.*
31. Esseks, *Op. Cit.* and Fletcher, *Op. Cit.*
32. Fletcher, *Op. Cit.* and Young, Louise B. 1973. *Power over people.* Oxford University Press, New York.
33. Smith, Thomas W., et. al. 1977. *Transmission lines: Environmental and public policy considerations.* University of Wisconsin Institute of Environmental Studies, Madison, WI.
34. National Association of Conservation Districts. 1979. *Tuesday Letter.* NACD, Washington, D.C.
35. U.S. Department of Agriculture. 1979. *Appraisal 1980: Review draft, part I.* Washington, D.C.
36. Paarlberg, Don. 1980. *Farm and food policy: Issues of the 1980's.* University of Nebraska Press, Lincoln, NE.
37. U.S.D.A., *Op. Cit.*
38. *Ibid.*
39. Tombargo, Francisco and Robert Young. 1978. *The Colorado River salinity problem in Mexico.* Journal of Natural Resources, January 1978.
40. U.S. Water Resources Council. 1978. *The nation's water resources: 1975-2000.* The Second National Water Assessment. USGPO, Washington, D.C.
41. *Ibid.*
42. Young, Robert. 1978. *Impact of increases in natural gas prices on irrigation in the Texas high plains.* In 25th Annual Proceedings of the Mid-Continent Research and Development Council. Colorado State University, Fort Collins.
43. Boone, Sheldon G. 1980. *Agriculture's use of ground water: Needs and concerns.* Unpublished paper presented at EPA Conference on developing strategy in the regulation of ground water, Arlington, VA, May 21-22.
44. Paarlberg, *Op. Cit.*
45. The White House. 1980. *Fact sheet: S.932, the energy security act.* (Public Law 96-294) Office of the White House Press Secretary, Washington, D.C.
46. Larson, W.E., R.F. Holt, and C.W. Carlson. 1978. *Residues for soil conservation.* In W.R. Oschwald (ed.) *Crop residue management systems.* Spec. Pub. No.31, Am. Soc. Agron., Madison, WI.
47. Larson, W.E. and F.J. Pierce. 1980. *Crop residues: Availability for removal and requirements for erosion control.* Unpublished paper presented at Bio-Mass World Congress and Exposition, Atlanta, GA.
48. Sampson, R. Neil. 1976. *Energy analysis as a tool in conservation planning.* In *Critical conservation choices: A bicentennial look,* Proceedings of the 31st annual meeting. Soil Conservation Society of America, Ankeny, Iowa.
49. Larson and Pierce, *Op. Cit.*
50. Fletcher, *Op. Cit.*
51. *Ibid.*
52. *Ibid.*
53. Blobaum, Robert, 1979. *Energy alternatives for agriculture. In Resource-*

constrained economies: The North American dilemma. SCSA. Ankeny, IA.
54. Commoner, Barry. 1979. *The politics of energy.* Alfred A. Knopf, New York.
55. Jackson, Wes, Mari Peterson and Charles Washburn. 1980. *Impacts on the land in the new age of limits.* The land report, No.9. The Land Institute, Salina, KS.
56. Zeimetz, Kathryn A. 1979. *Growing energy: Land for biomass farms.* Agricultural economic report No.425, U.S. Department of Agriculture, Washington, D.C.
57. *Ibid.*
58. U.S. Forest Service. 1976. *The nation's renewable resources—an assessment, 1975.* U.S. Department of Agriculture, Washington, D.C.
59. Crosson, Pierre. 1980. *Future economic and environmental costs of agricultural land.* Paper given at an RFF conference on the adequacy of agricultural land, June 19-20, Washington, D.C. (to be published by RFF).
60. Cited by Ziemetz, *Op. Cit.*
61. U.S. Department of Energy. 1979. *The report of the alcohol fuels policy review.* DOE/PE-0012. Washington, D.C.
62. Brown, Lester R. 1980. *Food or fuel: New competition for the world's cropland.* Worldwatch paper 35, Worldwatch Institute, Washington, D.C.
63. Bergland, Bob. 1979. Testimony before the House Committee on Science and Technology, May 4, 1979, Washington, D.C.
64. U.S. House of Representatives. 1979. *National fuel alcohol and farm commodity production act of 1979.* Hearings before Subcommittees of the Committee on Agriculture on H.R. 3905. Washington, D.C.
65. Office of Technology Assessment. 1979. *Gasohol: A technical memorandum.* Congress of the United States, Washington, D.C.
66. U.S. Department of Energy. 1979. *Op. Cit.*
67. Jackson, *Op. Cit.*
68. Williams, Jim. 1980. Statement before the Committee on Science and Technology, House of Representatives, Feb. 22
69. Bergland, Bob. 1980. Statement before the U.S. National Alcohol Fuels Commission, June 19, 1980.
70. Abel, Martin E. 1980. *Growth in demand for U.S. crop and animal production by 2005.* Paper presented at RFF Conference on the adequacy of agricultural land, Washington, D.C., June 19-20. (To be published by RFF).
71. Bergland. 1979. (Note 62).
72. Tankersley, Howard. 1980. Personal correspondence.
73. Hogan, Lemoyne, 1979. *Jojoba: A new crop for arid regions.* In Gary A. Ritchie (Ed.), *New agricultural crops.* AAAS Selected Symposia Series, Westview Press, Boulder, CO.
74. Nabhan, Gary. 1979. *New crops for desert farming.* The New Farm, Vol.1, No.3.
75. Vietmeyer, Noel D. 1979. *Guayule: Domestic rubber rediscovered.* In Ritchie, *Op. Cit.*
76. Nabhan, *Op. Cit.*
77. Bemis, W.P., James W. Berry and Charles W. Weber. 1979. *The buffalo gourd: A potential arid land crop.* In Ritchie, *Op. Cit.*
78. Nabhan, *Op. Cit.*
79. Princen, L.H. 1979. *New crop developments for industrial oils.* Journal of the american oil chemists' society, vol. 56, no. 9.
80. Princen, L.H. 1977. *Potential wealth in new crops: Research and development. In* Crop resources, Academic Press, New York.
81. *Ibid.*
82. Princen, L.H. 1980. *Alternate industrial feedstocks from agriculture.* Northern Regional Research Centre, SEA-AR, USDA, Peoria, IL; 1977. *Need for renewable coatings raw materials and what could be available today.* Journal of coatings technology, vol.49, no.635. See also 87 and 88.
83. Princen. 1980. *Op. Cit.*
84. Little, Charles E. (Ed.) *Land and food: The preservation of U.S. farmland.* American Land Forum, Washington, D.C.
85. Brewer, Michael and Robert Boxley. 1980. *The potential supply of cropland.* Paper presented at RFF Symposium on the adequacy of agricultural land, June 19, Washington, D.C.
86. Timmons, John F. 1979. *Agriculture's natural resource base: Demand and supply interactions, problems, and remedies.* In Max Schnepf (ed.), *Soil conservation policies: An assessment.* SCSA, Ankeny, IA.
87. Bergland, 1979, *Op. Cit.*
88. Sampson, R. Neil. 1979. *The ethical dimension of farmland protection.* In Max Schnepf (Ed.) *Farmland, food and the future.* SCSA, Ankeny, IA.

ACKNOWLEDGEMENT
This paper was first presented at the Soil Conservation Society of America's 35th Annual Meeting.

THE NUCLEAR ECONOMIC FRAUD

by J.W. Jeffery
Professor of Crystallography, formerly Birkbeck College, University of London

In *The Ecologist* December 1981 we published the findings of the Committee for the Study of the Economics of Nuclear Electricity (CSENE). The Committee's conclusions were that if the published generating cost figures for nuclear power and coal-fired plant were calculated so as to take account of inflation, then nuclear power's supposed economic advantage turned into a significant generating cost disadvantage. Thus, when compared with contemporary coal-fired plant, Britain's Magnox stations were as much as 50 per cent more expensive to build and operate and the Advanced Gas Reactors from 45 to 70 per cent more expensive, depending on the extent of the cost-overruns.

As for Britain's intended nuclear power stations, whether the two new AGRs at present under construction, or the Pressurised Water Reactors likely to follow on from the Sizewell Planning Inquiry decision, their construction and operation would lead to a loss of as much as £2,000 million over the station's lifetime, given reasonable assumptions on capital costs and on nuclear and coal fuel costs.*

In this article, Professor J.W. Jeffery, consultant to CSENE, takes the argument further by showing that the pursuit of nuclear power in Britain, both because of the large size of plant under construction and because of the inevitable reduction in coal-burn implicit in a growing commitment to nuclear power, is leading to unnecessary, and substantial increases in the cost of electricity to the consumer. Moreover, in order to make a better showing with the economics of nuclear power, the CEGB has transferred some of the nuclear fuel costs out of the revenue account. Thus, the full nuclear fuel costs are not revealed in the current cost accounting generating cost figures, and the comparison costs, as Professor Jeffery points out, are anyway published by the CEGB in historic cost terms, and hence give no indication of the true value of money when spent.

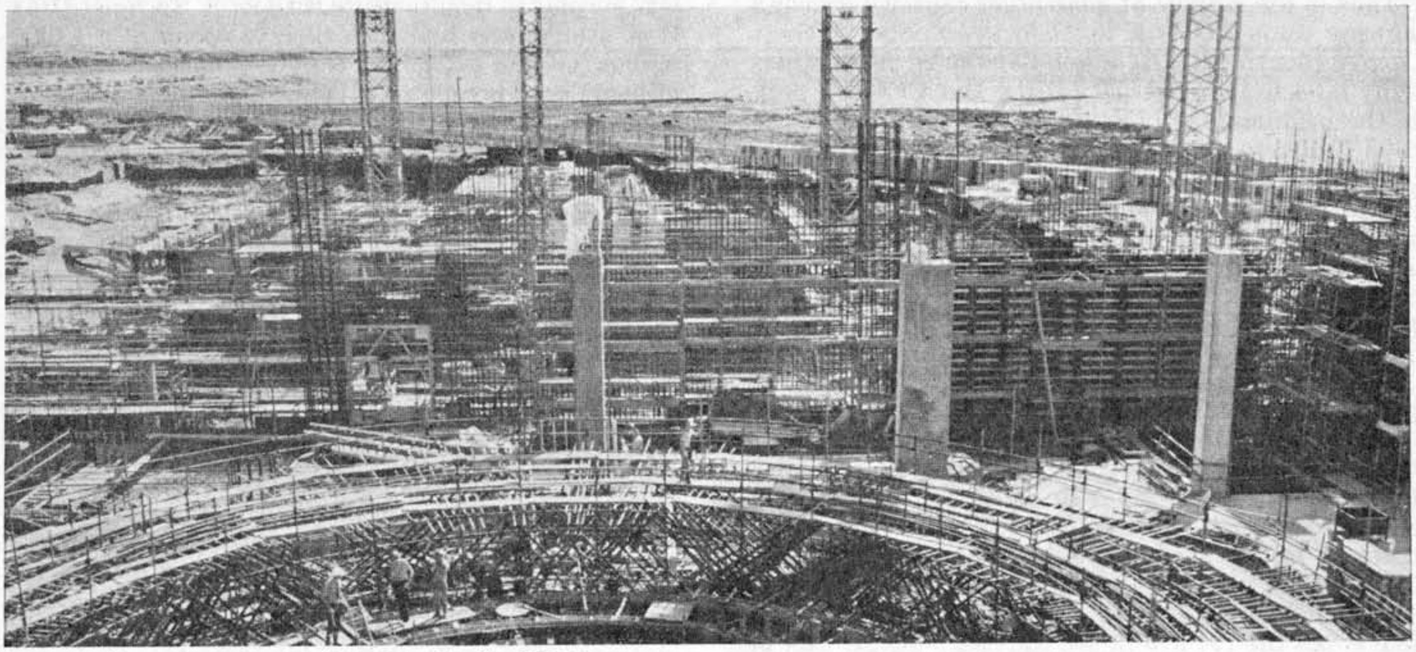
Overall, therefore, the British electricity consumer is being duped into believing that the Electricity Generating Board is striving to provide him with electricity as economically as possible. On the contrary, the consumer would be better off if the nuclear programme were completely abandoned before construction proceeds further.

*The Real Costs of Nuclear Electricity in the UK, *Energy Policy,* 1982, No. 2

Innumerable brochures, glossy booklets and leaflets have been produced by the Electricity Council, the CEGB, UKAEA, the British Nuclear Forum and others with the alleged cheapness of nuclear power as a constant theme. Answers to Parliamentary Questions repeat the CEGB figures and these have been widely broadcast in the media. One particularly blatant example is "understanding Electricity—the need for Nuclear Energy", a lavishly illustrated booklet produced by the Electricity Council in December 1979, specifically for "school and college use".

Not content with stating "nuclear energy . . . is cheap . . . Electricity produced in nuclear power stations costs less than electricity from power stations burning coal or oil"—with no hint of any kind of proviso—the same page has a diagram of a 10p piece with three segments labelled, "oil 1.31", "coal 1.29" "nuclear 1.02". The segment for coal is over twice the size of that for nuclear. These phoney figures, products of "the fraud inherent in all inflationary finance" have been strenuously defended by the CEGB. Since they form the basis for the enormous propaganda effort in favour of nuclear power, that defence is not surprising.

Nor is it only the CEGB which is responsible for misleading the public in this way. The UKAEA, which might be expected to take a more objective approach, in a 1980 pamphlet giving "The authority's comments on the *ECOROPA* questions and answers" makes the categorical statement "Although the capital and operating costs for nuclear power stations are higher than those for fossil fuel stations, their fuel costs are much lower. The net result is that nuclear generating cost is lower than for oil and coal, and this will continue to be true for future stations". In *Atom,* January 1981, the UKAEA supports the CEGB's claims for future stations as being "confirmed by our own studies".


Heysham II — an unnecessary investment by the CEGB

Propaganda Money

The amounts of electricity consumer's and tax-payer's money spent on "the distribution of information about nuclear power to the public" are not small. The Parliamentary Under-Secretary of State for Energy stated in Parliament that the UKAEA expected to spend £650,000 in 1980/81 (itself £300,000 more than in 1979/80) and that the Nuclear Power Information Group were spending £100,000. Meanwhile, the CEGB spent £2,325,000 on "Public relations and publicity" and the Electricity Council an additional £2,475,000 on "Publicity and Exhibitions" in 1978/80, all based implicitly or explicitly on the propaganda that nuclear electricity was and would be cheap.

The Commitment of the CEGB to Nuclear Power

The overriding commitment of the CEGB to nuclear power is exposed in the different attitude the Board has taken over a new coal station, the second half of Drax (Drax B), compared to a new nuclear station (Heysham II).

Although the site had been prepared for the second set of three 660MW units at Drax and common services such as the main chimney already existed, the Board did everything in its power to avoid completing the station, on the grounds that it would be in advance of requirements. In the 1974/75 Report the Chairman stated that the Board "saw no justification for electricity consumers having to bear the extra costs of advanced orders". This was repeated two years later in the 1976/77 Report together with the statements that, (a) "The Board has been under mounting pressure to invest in new plant that it does not yet require" (paragraph 12) and (b) "Estimates of future electricity demand indicate that the Board will be able to maintain security of supply at the desired standard without commissioning any further plant until 1985. As a result, no new plant needs to be ordered before 1979" (paragraph 99).

In the same Report (paragraph 100), CEGB stated that in order to help the hard pressed power plant industry it was prepared to "discuss an undertaking to order two or three 660 MW units per annum of new plant for a five-year period from 1979 as its share of a national programme. This ordering programme would include the completion of Drax power station in Yorkshire. However, if the order for these three 660 MW coal-fired units was to be brought forward ahead of the need to satisfy electricity demand, the Board would expect the Government to provide compensation for the additional cost so as to avoid it falling on the electricity consumer."

In 1976/77, when, according to CEGB, no more capacity would be needed until 1985, their forecast requirement to cover maximum demand in 1985/86 was more than 55 GW (55.2 GW in the 1977/78 forecast). In the 1979/80 Annual Report the forecast was down to 48 GW, giving a 7 GW "bonus" on supply which should clearly stop any possibility of the five-year ordering programme that the CEGB had been prepared to discuss in 1977.

In the event, in July 1977 "the Government requested the Board to place orders for the completion of Drax power station in Yorkshire" and having extracted a promise of up to £50 million in compensation, the Board placed contracts in November 1978, thus achieving an advance ordering of two months before 1979! The whole of Drax B's 2 GW was to be completed by 1986, so that the CEGB would then be 9 GW better off than they thought they would be in 1976/77. There should therefore be an expected surplus of at least 7 GW above the planning margin in 1986. It might be thought that resistance to further ordering and demands for compensation would be intensified, but in the 1977/78 Report (paragraph 13) the Government "*agreed* that two early nuclear orders were needed which should be AGRs". The Government therefore decided to *authorise* the Board "to begin work at once with a view to ordering one AGR station as soon as possible (my emphasis). No "mounting pressure" needed here and no time was lost. Investment approval for Heysham II was received in June 1979 and "interim arragements were made for the fabrication of some major reactor components" before a license to proceed with the construction had been granted. "The Board aims to start work on site in August 1980 and to commission the first reactor in 1986" (1979/80 Report, paragraph 108.)

Thus is the surplus of generating capacity growing (already some 7 GW in 1985/86); even under Current Cost Accounting (CCA), it will have to be at least partially reflected in electricity costs. But CEGB is only at the beginning of building up this surplus. In the 1978/79 Report, after describing the work on Heysham II, paragraph 159 says, "There will be requirements for further plant—perhaps to a maximum of 2.5 GW per annum—beyond the current programme . . ." and in the 1979/80 Report, paragraph 106, "The Electricity Supply Industry had advised the Government that, even on cautious assumptions, they would need to order at least one new nuclear power station a year in the decade from 1982 or a programme of the order of 15,000 MW over ten years".

One reason given by the CEGB for it's commitment to nuclear power is that it offers a degree of immunity from the uncertainties associated with fuel price changes over the life of the plant". Yet real nuclear fuel costs (all figures in 1979/80 prices) have increased from 0.304 p/kWh in 1973/74 (when it was 30 per cent of the coal-fired fuel cost) to 1.241 p/kWh in 1980/81, over four times the 1973/74 figure and nearly 80 per cent of the coal figure in 1980/81.* Part of the increase is due to the adoption of CCA, but even allowing for that the increase from 1973/74 is 3.62 times, and the 80 per cent in 1980/81 is for CCA figures in both cases. If this sort of nuclear fuel price change can happen over seven years with no sign of it stopping, and if we add all the additional uncertainties involved in the reprocessing of AGR fuel (if and when THORP is built) and the inevitable increase in fuel fabrication costs, as BNFL overcapacity starts to take effect, then nuclear uncertainty is clearly far greater than that of coal.

The CEGB's answer to the criticisms above (letter of 3.2.82) is to emphasise that it "does not see the Drax coal-fired station and Heysham II nuclear station as providing the same benefits. In particular we see Heysham II as being part of the thermal reactor strategy intended to prepare a sound base for further nuclear orders . . ." No question of Drax being "a sound base for further coal-fired station orders". The justification still given for this in February 1982 is that Heysham II is expected to be economic (on energy cost savings alone "whereas Drax would not be and would therefore increase electricity costs, thus justifying a government subsidy."

The CSENE Report has shown how untenable this economic justification is, and as long as it is retained against all the evidence it continues to commit the CEGB to the development of nuclear stations only.

However, it is perhaps significant that this letter from the CEGB qualifies "further nuclear orders" by "if needed" and the expectation of being economic is reduced to "shows a good prospect". What is a good prospect clearly depends on who is the onlooker, but these are perhaps signs that the facts are beginning to be looked at even if somewhat askance!

There are two further points which need emphasising. The CEGB has not attempted to refute the demonstration above that it knew, when it rushed in indecent haste to start on Heysham II, that when that station was due to be commissioned it would have at least 7 GW surplus to requirements without it. To resist Drax B so strenuously and then rush to spend over £1000 million on the offchance that the nuclear station's alleged "good prospect" of being economic would come off, when such a surplus of generating capacity was known to be already available, is hardly evidence of impartiality.

The second point concerns the CEGB's desire to help the hard-pressed "UK power plant manufacturing industry" by agreeing "to order two or three 660 MW units per annum of new plant." There is no mention of "nuclear" or "coal-fired" plant or industry and that agrees with the industry's own view of itself. There is no such thing as a nuclear power plant manufacturing industry, but there is an inclusive power plant manufacturing industry which is as ready to make CHP coal-fired stations with fluidised bed furnaces as it is to build nuclear power stations. There is however, little sign that the CEGB is seriously looking into the possibilities of helping the industry in that direction. Instead it appears that the CEGB is far more concerned with camouflaging the real cost of its existing nuclear stations, as the next section demonstrates.

How to have Nuclear Electricity without paying for it

About 60 per cent of the cost of nuclear electricity in 1980/81 arises from fuel costs. Nuclear fuel costs arise from payments for materials and work already done in fabricating, etc., and payments into funds which are required for future work. This future work comprises: (1) *reprocessing of the spent fuel;* (2) *long-term storage of waste products;* (3) *reprocessing of fuel left in the reactor at the end of its life;* (4) *decommissioning the radioactive remains of the reactor.*

Since the necessity for a decommissioning fund arises from the nature of nuclear fuel, all costs of future work are essentially fuel costs, although decommissioning costs are always listed separately or with capital costs. The 1975/76 CEGB Accounts (Statement 1) under "Generation", state that "since 1 April 1973 and up to 31 March 1975 costs of reprocessing irradiated nuclear fuel and long term storage of waste products have been charged to Revenue Account as incurred". This is straightforward and since reprocessing is part of nuclear fuel costs, the inclusive nuclear fuel cost for the year would include the cost of reprocessing done during the year. However, from 1 April 1975 "the Board's policy is now to make provision for them when irradiated fuel is withdrawn" from reactors, at the rate ruling in that year. The reason for this change is given as "the rapid increase in such costs", but when the fuel withdrawn is finally reprocessed (same year or years later) it has to be paid for at the rate at the time of reprocessing. Since, in a time of inflation, and because of real reprocessing cost increases, this rate is higher than in the year the fuel was withdrawn, the amount set aside in the earlier year has to be topped up to the new price. The final price paid is the same as in the old system, but the first part is paid in a more valuable currency, so that in real terms more is paid for reprocessing. It is difficult to understand why the rapid increase in costs can be the reason for paying more, in real terms, for reprocessing, and it is much more likely that the breakdown in the Magnox reprocessing plant and the rising backlog of spent fuel means that some means of smoothing out the payments for reprocessing has had to be devised. Also, the splitting of the payment into two parts may open a way for a future separation into two different

*From the 1980/81 Statistical Yearbook, tables 9 and 10, coal fuel cost = 1.69p/kWh. Total nuclear fuel cost = "Inclusive fuel cost" 1.07 + "topping-up" fuel cost (Accounting provisions relating to previous years') 0.26 = 1.33p/kWh. This is 79 per cent of coal fuel cost. See *"How to have nuclear electricity without paying for it"* below, for details.

categories, with the "topping up" payment treated as though it is not a fuel cost at all, but some sort of "Accounting provision relating to previous years", which, in some cases, will not even be charged to Revenue Account. We shall see that this is precisely what has been attempted in the 1980/81 Accounts.

Looked at in another way, part of the work associated with the use of nuclear fuel must be done some time after removal from the reactor because of the physical nature of the process (the necessity for a cooling off period possibly enhanced by the extreme difficulties of the chemical manipulations leading to breakdown and the building up of a backlog of spent fuel awaiting reprocessing). As prices are rising owing to a combination of real cost increases and inflation, and as any fund established for later payment for such work must remain adequate, it is necessary to invest the fund so as to produce interest at the rate of inflation plus real cost increase. In the case of (3) and (4) (possibly also (2)) above, a real rate of interest of 5 per cent is built into the calculation of annual cost, so that for these funds 5 per cent must be added to the interest rate.

To a layman, the obvious way to deal with this on an accounting basis is to incorporate the fund as part of the CEGB's internal nuclear investment and to charge the necessary interest to the nuclear account. In effect this is what has been done in the past. In the words of the 1979/80 CEGB Accounts, Statement 1, paragraph 2, "These provisions (for (1), (2) and (3) above, in the Revenue Account) include adjustments to provisions made in prior years to reflect current prices". For a large backlog of reprocessing this "topping up" can become a large proportion of the total nuclear fuel costs. In 1980/81 it was 25 per cent of the so-called "inclusive fuel cost" (the total nuclear fuel cost less the "adjustments". See footnote on previous page). No AGR fuel will be reprocessed until the late 1980s, so that inflation and the almost inevitable real cost escalation will mean that large "adjustments" will accumulate for AGR fuel as well, even in the unlikely event of THORP getting built on time and to cost.

Hiding the real Nuclear Costs

The separation of nuclear fuel costs into these two parts is described in detail in *Energy Policy* 1982, No.2, What is artificial is the separation of the actual payment for reprocessing into a payment in the year when the fuel is withdrawn and a topping up payment (treated as though it were not a fuel cost) when reprocessing actually takes place and is paid for. Such a separation may be convenient for accounting, but even if there was no inflation the "topping up" payments would still be necessary because of the continuing large real increases in reprocessing costs.

It must be emphasised that here we are not discussing comparisons of real costs, but are analysing what has actually happened, including the effect of CCA, and what is likely to happen in the future; and we are tracing the £57 million of nuclear costs in 1980/81 which has not been charged to Revenue Account.

The formal separation in the 1980/81 Statistical Yearbook of the preliminary payment for reprocessing and the "topping up" payment, with the deliberate attempt to present the latter as an "accounting provision" and not a fuel cost, lays the basis for treating part of the "topping up" requirement as not needing to be charged to the Revenue Account.

Statement 1, paragraph 8, "Long-term provisions", in the 1980/81 Accounts, states: "Because of the long term nature of the following provisions, adjustments in respect of prior years to reflect current prices are charged to Current Cost Reserve: reprocessing of residual fuel; reprocessing of advanced gas cooled reactor fuel burnt where no reprocessing is anticipated to occur prior to 1990; long-term storage of waste products; closure of nuclear power stations."

The Current Cost Reserve is a completely new fund (96 per cent "unrealised") which did not exist on 31st March 1980. It is completely separate from the Generating Reserve, which accumulates profits or losses from the Revenue Account. How this accountant's artefact can provide for reprocessing after 1980 is unexplained. Why should it be necessary to provide "adjustments in respect of prior years" from Revenue Account for Magnox reprocessing and for AGR reprocessing in 1989, when the CC Reserve can somehow provide it for AGR reprocessing in 1990? On what basis do "long-term" provisions start in 1990?

It is difficult to avoid the conclusion that nuclear provisions which should have been charged to Revenue Account have been shunted on to CC Reserve to the tune of £57 million (£11.3m for decommissioning and £45.6m for "long-term reprocessing of irradiated nuclear fuel and waste storage"—1980/81 Accounts, page 49, bottom). The reasons for doing that are not hard to understand. The government CCA target for the operating profit of CEGB is 1.8 per cent of the net value of assets in use averaged over the three years to 1982/83. Even after removing £57 million from the debit side of the Revenue Account the operating profit in 1980/81 was only 1.2 per cent. If these nuclear fuel costs had been charged to Revenue Account as in previous years (and as the adjustments for Magnox and AGR fuel up to 1990 have been in the 1980/81 CCA Accounts) then the operating profit would have been only 0.85 per cent—less than half the target average. The overall loss (after interest payments) would have increased from £281 to £338 million.

The Effect of Nuclear Power on Coal Prices—The dilemma of nuclear power and dear coal or restricted nuclear power and cheap coal

The CEGB nuclear stations under construction (except for Heysham II) should be completed and settled down by 1983/84. What is a reasonable estimate of the total CEGB load in TWh in that year? The circles in the figure show the Electricity Council forecasts adopted, in the years shown along the bottom, of the CEGB's expected load in 1983/84. (See CEGB *Annual Reports*). The crosses show the actual load in the year of forecast. These curves should meet in 1983/84. While neither curve need be linear, (in fact fluctuations especially on the bottom curve, are to be expected) the possibility of the load in 1983/84 being 190 TWh cannot be ruled out. On the evidence plotted on the chart it is clearly the most likely outcome. We shall therefore use this assumption. The effects of variations up or down can be easily calculated.

The calorific value of CEGB coal can be calculated from Table 9 of the CEGB's Statistical Yearbook (SY). For 1980/81 it was 6.7 TWh/mte. Assume that coal-fired stations displaced by nuclear have an average efficiency of 29 per cent. Then 1 TWh (e) displaced will mean 1/(0.29 x 6.7) = 0.51 mte less coal used. Taking the existing average coal-fired efficiency of 32 per cent, 190 TWh load in 1983/4 $\equiv$ 190/C0.32 x 6.7) = 88.6 mtce as the total fuel corresponding to this output.

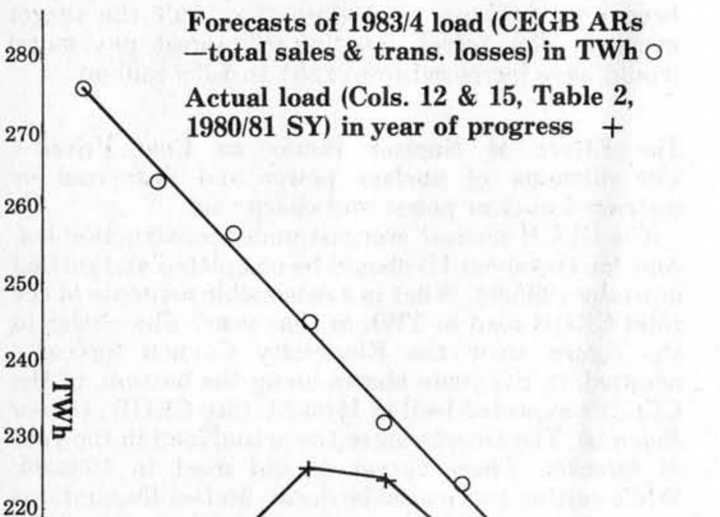
Oil burn has reduced from 17.5 (1978/79) to 8.1 mtce (1980/81). Even if oil prices rise again in real terms it is doubtful whether it would be justifiable to burn less than 5 mtce given the existence of new, high efficiency oil plant which has proved to be remarkably flexible in operation.

Assuming that Magnox stations can achieve again the 1978/79 total of 21.4 TWh and that all four AGRs are in operation at 54 per cent load factor, the total production will be 45.6 TWh $\equiv$ 45.8 x 0.51 = 23.4 mtce. The coal burn would then be in 1983/84 88.6 — 5 — 23.4 = 60.2 mte.

Even if no oil were burnt, the total coal burn would only be 65.2 mte, 10 million tonnes short of the 75 mte required by the 1979/80 "understanding" with the NCB.

The first "understanding" was described in the 1977/78 CEGB Annual Report, paragraph 12, as follows: "the Board has undertaken to accept a record 72 million tonnes of NCB coal in 1978/79. This is over 3.5 million tonnes more than the amount taken in 1977/78. The Board gave this undertaking even though the power stations were holding record stocks of coal at the end of March 1978. The main condition attaching to the undertaking is that the price of NCB coal to the CEGB should not be increased during 1978/79."

The pressure on the CEGB to take more coal is fairly obvious and in 1979/80 a similar "understanding" was entered into which would stabilise the real price of coal to the CEGB provided it accepted a minimum of 75 mte a year (3m more than in the previous year) for five years. The Monopolies and Mergers Commission (MMC Report, paragraph 7.114) welcomed the understanding and recommended "that the Board should



seek to improve the terms and extend the duration of the understanding". It is difficult to see this extension happening without an increase in the minimum amount of coal to be accepted, perhaps to 80 mte per annum.

If Heysham II and the PWR were to come into operation at 68 per cent load factor, a further 2.5 x 0.68 x 0.365 x 24 = 14.9 TWh $\equiv$ 14.9 x 0.51 = 7.6 mte of coal will be displaced, assuming the same total load. This, in the worst case, would mean a shortfall in coal take of 27 mte per annum. If shortfalls of the order of 20-30 mte of coal should occur there will clearly be a major crisis in the coal industry likely to cause widespread disruption. The price of coal to CEGB would certainly not remain constant and we might get another jump in real costs, as happened around 1974/75, of 40-50 per cent.

The Effects on Electricity Costs

Two main cases can be identified for a first investigation:

(a) the use of 75 mte of coal (160.8 TWh) with constant prices and restricted use of nuclear stations:

(b) the maximum use of nuclear power, with the consequent shortfall in coal consumption and rise in coal price of 40 per cent.

Approximate calculations of the cost of electricity in the two cases in the year 1983/84, in the 1979/80 prices of *Energy Policy* 1982, No. 2, are attempted below. A number of simplifying assumptions have to be made and these need to be borne in mind in interpreting the results. For simplicity it will be assumed that there is no oil-fired electricity production.

Even in this early stage of the difficulties arising from not taking the agreed quantity of coal because of the headlong development of nuclear power, the effect is to increase the real overall cost of electricity by 20 per cent. Since the widespread disruption resulting from such a policy would decrease electricity consumption even more, this must be considered a minimum effect. It does not take into account either Heysham II or the proposed PWR. The increased cost of electricity from pursuing (b) rather than (a) in 1983/84 would be £703 million in 1979/80 prices.

The Future of Coal Prices and Subsidies

There is a considerable difference in the cost of coal from different mines in the UK. The miners have made it clear to society as a whole that they will produce coal only on the condition that no mine is closed while there are miners willing and able to extract coal from it. The difference between the cost of coal if it was produced from the pits with the best conditions and the average cost is made up by a social subsidy which is, with reason, paid by society as a whole through the Exchequer. It is doubtful whether any of those who may object to this procedure would be prepared to replace the miners at the coalface.

The miners have been exhorted to increase production and productivity and have done so. If the coal available is not used, then an additional subsidy, which may be called an economic subsidy, will be required to enable the excess coal to be sold for export on the world market.

This subsidy ought to be paid by those responsible for there being a surplus. Firms which have failed to change from oil to coal should pay their share of the economic subsidy, and in particular nuclear costs of the CEGB should bear the economic subsidy on any shortfall on 75 million tonnes of coal per annum. If the economic subsidy is £10 per mte, a shortfall of 15 mte of coal in 1983/84, would add £150 million to costs of nuclear electricity in that year. If the 75 mte of coal is taken each year there is no reason why the cost to CEGB should rise in real terms.

Summary of the Costs of Building Nuclear Power Stations

One particularly important cost, is a direct consequence of large generating stations. Thus, the cost of building 6 GW of additional stations (as a result of increasing the planning margin from 14 to 28 per cent over 25 years) in order to cover the possibility of larger and larger stations being out of action, in March 1980 prices for nuclear stations, is £6000 million.

Because of the poor performance in practice of large stations, it is extremely doubtful whether any economies of scale have actually been achieved to counterbalance this cost.

The whole of the development of Magnox and the original four AGRs was unnecessary. The expected total capacity is now at most 80 per cent of the design 10 GW = 8 GW. To accommodate this nuclear generating capacity, 8.7 GW of "accelerated" (i.e., premature) closure of older fossil fuel stations has taken place. Even though some of this capacity would have been closed later and therefore not available, there would still have been 8.4 GW additional capacity surplus to planning requirements in 1988 (*Energy Policy* 1982, No. 2, Note 14). The original 10 GW of nuclear investment is therefore clearly unnecessary. In 1980 prices, this is £10,000 million unnecessary investment.

Although inflation has relieved the CEGB of much of the real cost of these unnecessary investments, Current Cost Accounting (CCA) is at least partially correcting for this and in the 1980/81 Accounts, Depreciation, (which was £303 million in historic cost terms in 1979/80) had become £690 million in CCA—an increase of 127 per cent. Interest is not greatly affected by CCA; it was greater indebtedness and higher interest rates which increased interest charges from £346 million in 1979/80 to £449 million in 1980/81—an increase of 30 per cent. However, the government's limit on external borrowing, which means that in 1981/82 £220 million of earlier borrowings should be repaid, means also that the Board's total requirement for capital in 1981/82 "around £1000 million, will need to be met from internal sources" (i.e., from increasing the price of electricity). Since the requirements for capital are mainly for unnecessary power stations (Drax B and the even more expensive and unnecessary Heysham II), the total unnecessary expenditure is enormous.

An idea of the unnecessary expenditure can be ascertained by comparing the average cost of generating a unit of electricity in 1979/80 prices (1.51 p/kWh from the weighted average of Tables 1 and 2 of Appendix 2 in the CEGB 1979/80 *Annual Report*) and the "Average charge per kWh sold" in 1979/80 of 2.14p, a difference of over 40 per cent, or £1332 million per annum.

The cost of Heysham II will be similar to that calculated for a new nuclear station in *Energy Policy* , i.e. a NEC of +£88/kW per annum. This is equivalent to £1636 million present value loss over the station's lifetime. The stopping of construction at considerably smaller cost would prevent even further increases in electricity costs.

If a decision is taken to build a PWR the comments on Heysham II apply with even greater force, since no construction costs have yet been incurred.

Future costs, if nuclear stations are built, have been dealt with in the section on *The Effect of Nuclear Power on Coal Prices.* By 1983/84 the additional cost may be £700 million per annum.

Minimum total Costs

The sections above do not attempt to do more than give some indication of the economic costs of nuclear power in various aspects. Some are total costs, some annual. Both overlap. For a minimum annual figure of the costs involved in building nuclear stations (and to a limited extent including costs of building large stations in general), one can take the figure of £1332 million derived above. It is a minimum because the CEGB's figures in Appendix 3 of its 1979/80 *Annual Report*—a point also true of Appendix 4 of its 1980/81 *Annual Report*—are historic costs, as are the corresponding figures from the 1979/80 Accounts, and for historic costs inflation reduces the effect of unnecessary investment. A reduction on account of inflation will almost certainly more than offset the effect of assuming that the stations of Table 1 and 2, Appendix 3, generate all the electricity instead of the 60 per cent actually produced in 1979/80. The other 40 per cent

Table 1

	Costs p/kWh Fixed	Fuel	1980/81	Output TWh (a)	(b)
Coal	0.45	1.27(1.78)	188.8	160.8	144.6
Nuclear	1.35	1.12	22.7	29.2	45.4
Total			211.5	190	190

		Fixed costs	Fuel Total p/kWh	Total Twh p/kWh	£m/10	Ave. Cost p/kWh
(a)	Coal	0.45 x 188.8/160.8	= 0.53 + 1.27 = 1.80	160.8 x 1.80	= 289.4	1.86
	Nuclear	1.35 x 22.7/29.2	= 1.05 + 1.12 = 2.17	29.2 x 2.17	= 63.4	
					352.8	
(b)	Coal	0.45 x 188.8/144.6	= 0.59 + 1.78 = 2.37	144.6 x 2.37	= 342.7	2.23
	Nuclear	1.35 x 22.7/45.4	= 0.67 + 1.12 = 1.79	45.4 x 1.79	81.3	
					424.0	

(b) is 20 per cent dearer than (a).

The cost figures used are averages of Tables 2 and 4 in The Real Cost of Nuclear Electricity, *Energy Policy*, 1982, No. 2 (Columns 2 and 1 for coal; 7 and 5 for nuclear respectively).

will have been produced by stations of somewhat higher cost which would decrease the difference if it were more than counter-balanced by the effect of inflation. By 1983/84 an additional cost of £700 million may have accrued as a result of CEGB failing to fulfil its side of the "understanding" with the NCB. We face in 1983/84 some £2000 million per annum unnecessary cost as a result of the nuclear commitment.

The Driving Forces behind the Nuclear Programme

The commonest reaction to the above analysis is, "If half what you say is correct why on earth is anyone proposing a PWR at Sizewell?"

Without doubt one of the reasons is prejudice against the coal miners, who are suspected of being about to hold the CEGB to ransom! This is normally only expressed in very indirect terms, but in the heat of discussion at the 1978 Royal Institution Conference on Nuclear Power and the Energy Future, Dr. N.L. Franklin, Chairman and Managing Director of the Nuclear Power Company, said, "I would ask him whether he thinks that, in terms of dependability, of output against social disturbance and strife, he would prefer to put himself in the hands of a number of large mines operated by miners or a number of (nuclear) power stations operated by the Electricity Authority?"

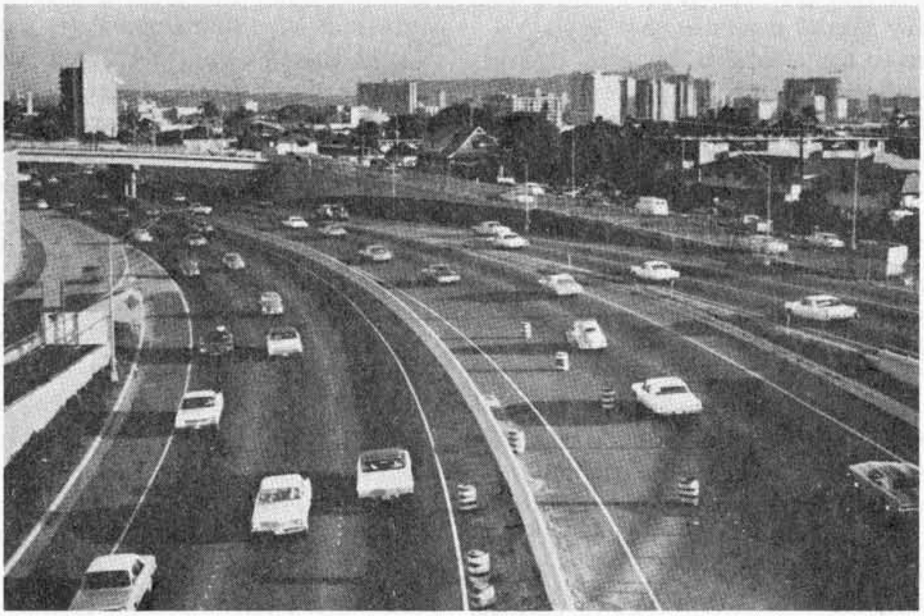
It is doubtful whether this prejudice has much more than a surface effect, because a little consideration must show that the industry is in the hands of the miners now, in that sense, and they are unlikely to remain passive while nuclear power erodes their jobs. However, as a first reaction it is probably quite widespread and the leaked Cabinet Minute of 23.10.79, stating "But a nuclear programme would have the advantage of removing a substantial portion of electricity production from the dangers of disruption by industrial action by coal miners or transport workers", shows that it has some importance in making a nuclear programme appear ideologically desirable.

More important in the long run is the sheer momentum and long time scale of the nuclear operations. The difficulties involved in stopping the nuclear programme should not be underestimated, even if existing stations continue to be used. Contracts for future uranium supplies are made long in advance; the enrichment company, Urenco (jointly owned by Britain, the Netherlands and West Germany) has been given contracts for the period 1980-94, and a contract has been placed for 1000 tonnes separative enrichment work in the USSR over the period 1980-1990. BNFL has planned a reprocessing plant for AGR or PWR fuel for the period well into the 90s. How much of all this is for fuel from existing power stations (including those under construction) is not known, but some will certainly be for fuel from projected future power stations. BNFL's ten-year investment programme is £3500m, but on the company's inflation projections, the actual outlay could be approximately £6000m (*Hansard*, 16.11.81 column 90). Even keeping the nuclear generation at its present level will involve much contract alteration.

The momentum can also be seen in the appointments. A "Director of the PWR project" has been appointed, who has not only "central responsibility for the technical adequacy, programme and cost of the PWR", but also for "planning and implementing all the CEGB initiations necessary for the successful launching of the PWR in the UK" (*Atom*, August 1981). There is even a "PWR Technical Officer" based at Sizewell who describes himself as such in the local press.

It should be said on the economic aspect of the programme that while it was known that Magnox stations would not be competitive with coal-fired stations (which did not prevent the artefacts of inflation being used as propaganda for nuclear power) it was genuinely and reasonably expected in the early days that ACRs would be cheaper. In that event, the economic forecast has not materialised. Instead the CEGB has had to resort to an elaborate "systems" exercise in which it has postulated a 36 per cent increase in coal costs over 1980-86 at the same time as the understanding with the NCB has been negotiated which practically guaranteed that there will be no increase in this period.

The sum total of the forces driving the nuclear programme forward is very great and it is to be hoped that it is not so strong that only disaster will stop them—either physical disaster as in Three Mile Island, or financial disaster as in the Washington Power Supply System, whose five nuclear plants have risen from an early 70s estimate of $4000 million to more than $25000 million, bankrupting many local authorities in Washington State and leading to two of the stations being moth-balled in mid-construction.



Technology and the Quest for Rational Control

by Peter Kauber

Bowling Green State University, Ohio, U.S.A.

In a market economy technology soon gets out of control: the very nature of modern technology and marketing methods sees to that.

Negative assessments of contemporary technology generally gravitate toward one of the following four generalizations: (1) modern technology is evil—the remedy is to abandon technology; (2) modern technology is evil, and its advance is inexorable and thus beyond the control of human society—there is no remedy because there is no independent agent capable of implementing one; (3) modern technology is itself neutral, and the issue of its good or evil consequences is essentially a matter of rational control—thus we need to develop more sophisticated mechanisms for evaluation and control; (4) modern technology constitutes a case of "too much too fast", and its evil consequences are predominantly a result of being big and fast—the solution is to replace these big-fast technologies with small- or intermediate-scale technologies.

While it happens that my own views are in accord with people who fall within the fourth category, it is those in the third to whom the following remarks are addressed—those who might with some justification be labelled "revisionists". For it is a concern with evaluation and control, rather than with size and speed, which characterizes the vast majority of commentators, those who would wish, for all sorts of good and bad reasons, to see the contemporary technostructure retained with as little alteration, adjustment, or displacement as possible. By designating technology as "big-fast", I do not mean to imply that contemporary technology is inherently so, although that may in fact be true to a degree. Technology manifests its big-fast character as a result of forces which are, more often than not, social in origin.

My thesis is that the solutions proposed by revisionists are doomed to failure, that accelerating technological innovation on a massive scale in effect undermines the only credible evaluation scheme currently available and, thus, that rational control is precluded simply because a scheme of evaluation has become progressively unavailable. In short, we are flying blind, not because people do not exercise rational control by way of rational decision-procedures, but because they cannot conceivably do so.

It is important to note at the outset that a considerable initial plausibility adheres to the revisionist stance. Emmanuel Mesthene, in *Technological Change,*[1] notes that neither the "optimistic" nor the "pessimistic" view of technology—whether technology constitutes an unmitigated blessing or an unmitigated curse—can withstand prolonged scrutiny, for the simple reason that the impact of technology is always "mediated" by society, and thus that the resulting character of applied technology is conditioned by that mediating element. That is precisely the strength of the revisionist position: having recognized society as mediator, the revisionist pushes on to rational control as his major concern. However, it should also be noted that there are other assumptions here, which are not nearly so evident; for even should society mediate, that is no guarantee that society is in control, since mediation may be in its nature *determined*, either by technology itself (as Ellul seems to suggest) or by some other factor(s). Further, even if we grant a measure of autonomous control to society, that is not to say that such control is, or even could be, rational.

By and large, the revisionist assumes that society's mediating values are to some extent "chosen" by individuals within that society—whether by democratic means or not—and thus side steps the thorny freedom/determinism issue. He then advances to advocate rational control, assuming also that the requisite notion of "rationality" can be substantiated.

For purposes of the present argument, I accept as a working assumption that society may indeed actively mediate, my concern however is to examine the question of *rational* control. The revisionist takes "rationality" and "technology" to be independent of one another and proposes to apply the former to the latter. My task is to show that they are not in all instances independent. In brief, I will argue that the revisionist's further assumption, that there exists an evaluative framework on the basis of which rational decision-making can be carried through, is unwarranted in the present context, simply because the very nature of the techno-structure he wishes to preserve undermines thoroughly such a framework.

To avoid establishing a straw-man, only to set fire to him, I must emphasize that revisionist tendencies are often manifested by thinkers and writers who are in no sense "pure types". Often a commentator with revisionist sympathies develops not merely an argument or programme for rational control over the uses or directions of contemporary technology, but further, applies similar arguments and programmes to technology in general, in terms of scaling down or decelerating these engines of production and change; or at least he mentions such an option in passing. But often it *is* in passing and nothing more, revealing a basic commitment to revisionism, that is, to minimal alteration and dislocation. Worse, he often treats the two problems—control over directions and control over size and acceleration—as if these are comparable concerns in the sense that identical or at least similar evaluative frameworks are available and applicable. But that is precisely the issue. What needs to be shown is that the relationship between the evaluative framework and the technology to be rationally assessed varies radically with the type and scale of the technology itself.

Consequence Analysis

Virtually all treatments of the question of the impact of technology on society, to the extent that these aim at value judgements, assume a *consequence analysis* as essential to an acceptable evaluative framework. Moreover, virtually all social scientists, as well as the majority of Anglo-American philosophers, agree either that consequence analysis comprises the sole credible scheme of evaluation, or at least that such an analysis constitutes a necessary (and major) portion of such an endeavour. That revisionists are among those who subscribe to such a position places them in the mainstream of the consensus.

Historically, the task of developing the theory of valuation has, with possible exceptions in the field of economics, fallen to philosophers, in particular to ethicists, who were as often as not engaged in other pursuits as well: science, literature, politics. For modern philosophy (from Galileo onwards), problems of ethics were subsumed under more fundamental ones in the theory of knowledge or epistemology. Thus the outline of a theory of valuation should follow closely, in its character and in its fortunes, major developments in epistemology.

What, then, were the relevant developments in epistemology? Fundamentally, it had been maintained that there were two avenues to knowledge: reason and the senses. The first was responsible for the intuitions and deductions associated with logic and mathematics, the second with empirical knowledge or knowledge "of the facts". We are thus left with three kinds of knowledge: intuitive, demonstrative (deductive), and empirical. One or another of these has been held basic, or fundamental, by most of the major thinkers of the modern period. In the early Enlightenment (17th century), "reason", and thus intuition and demonstration, were elevated; however as empirical science gained confidence, expertise, and, most of all, results, empirical knowledge rose in importance. In the Anglo-American world, as well as among many French and German thinkers, the eventual hegemony of science made philosophical empiricism dominant.

At the same time, intuition and demonstration were declining in repute for other reasons. With the accelerating changes brought about by European "progress", and with improved anthropological knowledge, it was becoming clear that the revelations of intuition were in many cases nothing other than the expressions of deep-seated historical and/or societal prejudices and thus were not "knowledge" at all. On the other hand, highly-regarded results in the philosophy of mathematics and logic led to the view that deductive reason yielded, not knowledge *of the world*, but knowledge about relations between abstractions. In short, intuition had become subjective, pure reason sterile.

Nevertheless, the "rationalistic" period spawned Spinoza with his "geometry" of ethics, and resulted also in a much increased interest in Natural Law, with its basis in intuition. The later empiricistic take-over is reflected in the ethical theory of utilitarianism, which remains the dominant theory *in practice* today. It is in reference to utilitarianism that I will develop my treatment of the analysis of consequences, that treatment being basic to my main thesis.[2]

There are many varieties of utilitarianism, but the core notion consists in the principle of utility, which asserts that our actions should be considered in the light of bringing about the most good that we can. Clearly then, utilitarianism requires of us that we perform an analysis of consequences, while measuring our results against some useful characterization of "the good".[3]

The appeal of utilitarianism to social scientists is straightforward. Because utilitarianism involves the analysis of consequences, and because the consequences of events are open to empirical test, utilitarianism, at least to that extent, is essentially amenable to scientific method. But its empirical character need not end there. Thus in determining "the good", either each member of the population can simply *announce* what is of value to him, the answer being gained through the empirical process of polling or opinion-surveying; or the "needs" of the populace can be ascertained *via* a scientific investigation of human nature, which, again, reduces the task to one of empirical dimensions. Generally, those with libertarian leanings and those who have faith in the ability of each to look after his own welfare opt for the former; those who are sceptical about those abilities turn to the latter. The important point is that under either of these interpretations the *whole evaluative project* is open to scientific methodology.

Nevertheless the reduction of ethics to epistemology has not been an altogether happy one. For, in the face of attempts to develop empiricist theories of value, some have argued that " 'Ought' cannot be derived from 'Is' ", claiming that such a derivation smacks of "emotivism". As a result, many social scientists have become wary of *admitting* to utilitarian leanings, but have gone on, in many cases, to practice what they fear to preach. *In practice* utilitarianism remains the credible theory of moral valuation for social science.

Utilitarianism

Utilitarianism involves an examination of consequences, but as we have presented it, utilitarianism is ambiguous, for are we to evaluate acts or policies, before they are implemented, or are we to do so "after the fact"? Are we to test all of the options, by anticipating the consequences of each, and *then* carry through the best option; or on the other hand are we to try out a particular option, ascertain what it accomplishes, and then either stick with it or try another, depending upon whatever it did accomplish?

Utilitarians have taken both positions. Historically, the choice has been more often in favour of the former interpretation. Jeremy Bentham, the founder of modern utilitarianism, provided an outline of a "hedonistic calculus", which was a device for ascertaining in advance which of several acts was more "right", which of them was justified on the basis of expected consequences. Bentham hedges somewhat on the requirement that such an analysis always be undertaken prior to acting, but clearly his ideal is what we might call the "pre-test":

> It is not to be expected that this process should be strictly pursued previously to every moral judgement, or to every legislative or judicial operation. It may, however, be always kept in view: and as near as the process actually pursued on these occasions approaches to it, so near will such process approach to the character of an exact one.[4]

It is not difficult to imagine why this should be a tough doctrine to implement, for we would have to become experts in predicting outcomes, masters of anticipation; whereas, prediction is hazardous. Realists have recognized the limits of pre-testing and thus have provided an escape. It takes the form of a distinction between "objective" and "subjective" rightness. The former applies to acts which have been carried out and whose consequences have *in fact* consisted in, or promoted, the general good. Subjective rightness, on the other hand, refers to acts which are committed on the basis of a reasonable assessment of the probable outcome, where that assessment indicates that the most good will be effected. Thus an act might be subjectively right but objectively wrong, the perpetrator having met his responsibilities, because he did the best he could. This bow in the direction of realism is acceptable, however, only on condition that some rough correlation exists in practice between subjective and objective right. Thus we should expect that *most* subjectively right acts will turn out to be objectively right also.

Some utilitarians, recognizing the limits (and in some cases the unfeasibility) of the pre-test version, come to prefer a "post-test" solution. William James, temperamentally on the look-out for cases involving inadequate evidence, penned the following allegiance both to utilitarianism generally and to its experimental side in particular:

> There is but one unconditional commandment, which is that we should seek incessantly, with fear and trembling, so to vote and to act as to bring about the very largest total universe of good which we can see.

And:

> These experiments are to be judged, not *a priori*, but by actual finding, after the fact of their making, how much more outcry or how much appeasement comes about.[5]

Here of course we have left the realm of subjective versus objective right: no pre-implementation evaluation is required, and the actual consequences are empirically available to within whatever limits science currently sets. While this circumvents the thorny issue of adequate anticipation and prediction, it raises equally serious questions about responsibility. In what does it consist, now that the facts are in and we are faced with a *fait accompli*? In what does "poor judgement" consist? Where pre-test consequence analyses are confronted with the problem of prediction, post-test analyses run the risk that the damage will already be done.

As we neither possess prescience nor wish to become latter-day sorcerer's apprentices, the logical move would be to adopt *both* pre-test and post-test proposals while striving to minimize the shortcomings of each. Fortunately, each version tends to rectify the faults of the other. It is irresponsible to initiate projects for which inadequate background material has been gathered and assessed; it is likewise irresponsible to undertake an endeavour whose actual results are ignored and/or irrevocable.

The Failure of Big-fast Technology to Stand the Test

Contemporary technology is essentially big-fast technology, and is thus dominated by the process of *innovation*. Thus all aspects of modern living are characterized by accelerating flux: the rates and modes of travel, the manner of harnessing energy, the proliferation of consumer products and consumer fads, the appearance of wholly new substances and industrial processes all testify to the increasingly swift introduction, diffusion, and turn-over of things and ways of doing. Increasingly too "unnatural synthetic" substances are being injected into the environment including non-natural elements and isotopes (especially radio-active ones), inorganic fertilizers, pesticides, detergents, plastics and synthetic fabrics and compounds of all sorts previously unknown in nature.[7] The rapidity with which technological innovation overhauls us has been illustrated by the drastic compression of the "discovery-diffusion" cycle—that is, of the time required for a technological discovery to be first recognized as important, then concretely implemented, and finally diffused throughout society. This cycle has become contracted to between one-quarter and one-third of what it was at the beginning of the century. That means a discovery will have impact three to four times faster today than it would have in 1900.

In fact, this innovative quality is no mere accident, nor is it in any other way *incidental* to contemporary technology. Innovation is now essentially inherent in the structure of our world and is the inevitable product of our new identities and basic institutions: scientific, military, economic, psychological-sociological.

If galloping innovation is a familiar sign-post of modern technology, so too is the extent to which such innovation diffuse into society. To a large extent this diffusion is simply a consequence of the gargantuan size of the major transnational corporations. As John Kenneth Galbraith puts it in *The New Industrial State*[8]: "Nothing so characterizes the industrial system as the scale of the modern corporate enterprise." He goes on to cite the evidence: that as of 1962 the 500 largest corporations controlled over two-thirds of all manufacturing assets in the nation; that by 1965 the gross revenues of each of the three largest corporations far exceeded those of any state and equalled a sizeable fraction of those of the federal government.

The purport of such size is *control*, not only over raw materials and prices, but equally important over quantity of sales. Size makes possible the requisite advertising, sales forces, and product design to insure customer demand. Efficient transportation, coast-to-coast mass media, and the relative homogeneity of retail outlets insures that a product can be introduced simultaneously to eager buyers in Boston, Atlanta, Spokane, and Los Angeles. Point-of-sale computer facilities insure that inventories are up-dated and adequate to diffuse the product just as rapidly as advertising can generate customer "need". Saturation is quick and assured. Any innovation introduced under the careful scientific management of a major corporation, under these conditions, can have scarcely less than massive impact.

In fact, as Galbraith shows, corporate size, which is the motive force behind market saturation, becomes a *requirement* dictated by the conditions of modern technology itself. Indeed, successful completion of an industrial venture now demands a long-range commitment of considerable resources: of capital, of materials, and of human talent. The only justification for such a commitment is the assurance that those resources will not be wasted in the end. That means, in turn, that the organization undertaking the venture must exercise control over the sources of supply, mechanisms of distribution, and ultimate market (in terms of price and quantity). Such control can be wielded only by organizations large enough to *dominate* the conditions of buying and selling. Thus size is not simply a consequence of the need to produce efficiently. Size is a product of the need to control. And such size virtually guarantees that the impact of an innovation will be massive in terms of comprehensiveness, in terms of saturation. It is in that respect that technology is "big". Finally, it should again be clear that bigness is a function of the fundamental conditions of contemporary society. The curtailment, or scaling down, of that feature would constitute a societal undertaking of considerable scope.

Technology uncontrollable

It can now be made clear why rational evaluation is largely incompatible with the conditions of current technology. The "fast" character of technology and its social support undermines the experimental nature of empirical evaluation by radically increasing the number of variables required to be taken into account (and hence the degree of uncertainty surrounding the whole endeavour) as a result of prior innovations; and by curtailing extended and comprehensive testing, as a result of explicit pressures working in favour of rapid diffusion of the item in question. The "big" character of technological society works to push diffusion beyond its "point of no return" and thus tends to violate that provision basic to empirical evaluation which asserts that such diffusion must never transcend the status of experiment.

Trouble arises at the very start of the evaluative process. The data which ordinarily set the parameters for experimentation must arise out of prior experience with the elements from which the object or process in question is comprised. But under conditions of extreme innovation, we often do not possess that kind of knowledge. Thus under conditions of rapid innovation we find ourselves encountering new substances whose combinations are poorly understood.

Meanwhile the second step in the evaluation process, experimentation, has increased in importance, simultaneously as the experiments themselves have become less straightforward. Under such conditions, the logical move might be to *extend* the time period of experimentation as well as to monitor results more carefully. Yet there are strong pressures against such proposals. First, any organisation which undertakes comprehensive pre-implementation experimentation runs the risk of being beaten to the marketplace by those who are less responsible in this regard. Second, the "technological imperatives" governing contemporary production dictate the long-term commitment of resources which Galbraith found to be characteristic of the operations of the large corporation. Such commitments, being justifiable only by some reasonable guarantee of ultimate success, tend to influence the results of the testing stage so that negative side-effects, should they be uncovered, are naturally played down, while an overly optimistic attitude develops regarding the capabilities of future technologies to resolve any potential long-range difficulty.

Even under the best of conditions—where background knowledge is abundant and where testing is thorough—the ever-present fallibility of consequence analysis dictates that diffusion be held within some (albeit vaguely defined) limit. In general, however, background information is scanty while testing itself is hurried and incomplete. Under such circumstances it should be of the highest priority to establish control over the diffusion of the product. Yet the market forces work entirely against the imposition of such safeguards.

Finally, those willing to accept the responsibilities associated with the later post-testing stages are faced with an awesome task. This task is to assess, on a continuing basis, the long-term effects of an innovation which, we recall, has been injected into an environment already overloaded with novelties. Such testing, were it responsibly carried out, could swallow up a quantity of resources which would dwarf that of the original implementations, while the "correction" of undesired conditions could conceivably become the sole occupation of an entire society of technicians.

Decision-making might be usefully broken down into three more or less distinct stages; first the hard-won empirical observations of science—the "hard data"—second, the conclusions to be drawn from such data—and third, decisions about what to do, in the light of the former stages and of values to be promoted. Excessive optimism concerning the accessibility of evidence is often felt by those who unwittingly substitute advances in data manipulation and decision-theory for hard data itself.

Certainly part of the problem stems from the mystique which continues to surround the computer. Computers have indeed made available rapid access to large quantities of data, and have provided a powerful tool for testing correlations among data, tests which otherwise would have been prohibitively time-consuming. They have also added considerably to the ease of generating models for interpreting and explaining such data. But these facilities in no way add to the *base of information* to be assessed and correlated. Thus if modern methods of data manipulation lead to an increase in the amount of available information, it is a mistake to assume that such manipulation can stand in the place of, and on an equal footing with, the hard data itself. In fact the first two elements in decision-making sometimes fail to be distinguished, and advances in data manipulation and model building can convince the unwary that adequacy of basic data is no longer a vital concern.

Then there are the "predictive" processes themselves, prediction being central to empirical evaluation. Much of the point in acquiring data is to aid the projection of probable futures. In general the accuracy of prediction varies with the adequacy of data *and* with the extent to which the predictive method is grounded on that data. With respect to the second condition, there is currently a considerable range of options. While prediction can rest firmly on empirical foundations, it can also take the form of a guess, a hunch, or an "intuition". But what possible credibility could attach to the latter? Perhaps our suspicions may be allayed once we learn that guessing can now be *organised*. For example, Alvin Toffler has described the so-called "Delphi" analysis in the following manner: since the futurist must often rely on guesswork, it is desirable to make the endeavour "rational" an "systematic." This is accomplished by selecting a panel of experts who are first requested, independently, to hazard their educated guesses about future events related to their fields of expertise. The responses of the other members are then "fed back to the participant so that he has an opportunity to revise his predictions on the basis of his knowledge of their opinions". The result is a "consensus . . . of expert opinion".[9] Thus the guesses of many are made coherent, leading to a super-guess. Now there is a sense in which all of this is sound *empirical* methodology. To the extent that each expert has at his command solid information upon which he is drawing, the Delphi method approximates the construction of a large, integrated data base. Further, there is no doubt that systematized and "rational" guesswork is better than nothing; for extremely long-range prediction, perhaps we can, as Toffler suggests, do little better. However, the end result *remains* largely guesswork, no matter how organized, and it must be appreciated that such procedures are in no sense an acceptable substitute for experimental method. The solution is not to make guesswork organized but to establish (or re-establish) the conditions under which *truly* rational decision-making can flourish. For the social scientist, this can mean nothing less than the establishment of conditions under which empiricism and experiment are both possible and relevant.

Finally, confusions may arise if decision-theory itself is misunderstood. Strategies for decision-making may aim at optimizing various factors: minimal risk or maximum pay-off, dispatch or thoroughness, facts or faith, expediency or breadth of perception. Methods may vary all the way from a strict dependence on fact to Pascal's wager and even coin-flipping. From the point of view of our evaluative scheme, it is epistemological soundness which is crucial to responsibility. It is facts that are required, and then decisions based upon them. Once again, novel approaches to decision-making will gain us nothing if they are but substitutes for the hard data which we require.

Nevertheless, utilitarianism—and consequence analysis in particular—continue to hold an appeal for social science: it is the essentially *empirical* character of the method which above all recommends it to those of scientific persuasion.

Thus the revisionist is initially committed to big-fast technology and intends to correct its mistakes through "fine-tuning"—by a more careful evaluation of options and by initiating choices to direct technology into the best of these options. Yet empirical evaluation, to be responsible, demands that innovations be subjected to continuous experimentation and that their impact be strictly limited. Big-fast technology works to undermine the conditions under which either demand can be met. Thus the revisionist maintains simultaneous allegiances which are incompatible. He can of course drop his evaluative model. In that case, and barring the instantaneous discovery of an alternative, one which is both compatible with big-fast technology and credible to social science, his stand will be deemed irrational. But revisionists include within their ranks those who realise that the desired control will require rather more than the minor adjustments initially anticipated. The revisionist now sees that he may need to slow down the technological engine, but can offer no realistic proposals in this regard, simply because he fails to recognize (or fails to acknowledge) the extent to which big-fast technology is intimately related to the basic institutions of our society. Were he to see this, and were he to continue his quest for rational control of technology, he must find himself committed to societal overhaul—and that is to abandon revisionism.

References

1. Emmanuel G. Mesthene, *Technological Change* (New York: Mentor Books, 1970).
2. It should be noted, however, that most of what is said here is likewise appropriate from the perspective of enlightened egoism—that is, rational evaluation need not be chained to ethics.
3. Since there is potential conflict between the promotion of the greatest *amount* of good and the promotion of the good of the greatest *number*, I will interpret utilitarianism as holding to the former. For discussions of this question, see W.K. Frankena, *Ethics*, 2nd Edition (Englewood Cliffs: Prentice-Hall, 1973), chapter 3; Paul W. Taylor, *Principles of Ethics* (Encino, Calif.: Dickinson Publishing Co., 1975), chapter IV.
4. From Jeremy Bentham, *An Introduction to the Principles of Morals and Legislation* (London, 1823), chapter IV, section VI; reprinted in A.I. Melden, ed., *Ethical Theories* (Englewood Cliffs: Prentice-Hall, 1955), pp. 360-361.
5. William James, *Essays on Faith and Morals* (Cleveland: Meridian Books, 1962), pp. 209, 207.
6. From John Stuart Mill, *Utilitarianism* (London, 1863), chapter II; reprinted in Melden, *op. cit.*, p. 380.
7. See Barry Commoner, *The Closing Circle* (New York: Bantam Books, 1972), especially chapter 9.
8. John Kenneth Galbraith, *The New Industrial State* (New York: Signet Books, 1968), especially chapter VII.
9. Alvin Toffler, "Value Impact Forecaster—A Profession of the Future," in K. Baier and N. Rescher, *Values and the Future* (New York: The Free Press, 1969), pp. 7-8.

Books

Facts and Figures

PLANNING MARGINS AND SECURITY OF SUPPLY STANDARDS: AN INTERNATIONAL SURVEY OF ELECTRIC UTILITIES, Commissioned by The Electricity Consumers' Council from Earth Resources Research Ltd., Available from: Electricity Consumers Council, 119, Marylebone Rd., London NW1. £5 inc. p&p.

1981 was a bad year for the CEGB. Two major Government reports were highly critical of their investment appraisal techniques, ordering programmes and foreward planning abilities. The Select Committee on Energy saw that the current planning margin of 28 per cent was likely to "increase the resource cost imposed on the economy". It urged that the planning margin be reduced to a "much lower level as soon as practicable" and envisaged two major routes towards this goal: an increase in plant availability and a review of the security of supply standard by the Government rather than the CEGB.

This report, commissioned by The Electricity Consumers' Council, represents a valuable contribution towards reviewing the relationship between planning margins and supply standards. It is to be hoped that its cautious recommendations will be taken into account and that policy will be revised accordingly.

The cautious nature of the reports conclusions stem as much from the secrecy of the CEGB as anything else. The utilities of France, South Africa and five American companies all supplied data for the report. The refusal of the CEGB and SSEB to supply detailed information contrasted sharply with the co-operation of the American utilities — exposing the line that information cannot be given 'for commercial reasons' as a myth. Despite this refusal the report manages to produce a wealth of information comparing, amongst other things, plant mix, systems load factors, plant availability, simultaneous maximum demand, and the security of supply standards adopted by the various utilities.

From this several things are made quite clear. Generation failures are a relatively insignificant source of failure of supply and the CEGB's plant availability has increased in the past two years making a reduction in the planning margin possible. Despite this, in its 'Loss of Load Probability' analysis the CEGB has to take into account the type and size of generating units which it is planned to add to the system. As the 1979 CEGB Development Review stated all future order will be nuclear and so a high planning margin become necessary. Diversification into smaller urban cogeneration sets with higher thermal efficiency and availability would enable a reduction in the margin.

The security of supply standard employed by the CEGB is found to be 'more stringent' than those of the other utilities studied. The CEGB's standard is designed to ensure that load management or disconnections are required on no more than 4 winter peaks *per century.* EDF plan on a basis of 8 such peaks and the US utilities 10. The report suggests that a similar level of 8-10 peaks per century could be adopted by the CEGB without significantly effecting the supply service to the consumer. This would reduce the planning margin to 24.5 per cent. A modest reduction but one well worth achieving when every one per cent is equal to 1,100 MW installed capacity or £1.5 million capital investment.

The CEGB is against any reduction and, admittedly, has neither the reserve hydro power of EDF nor the option of buying in power from elsewhere as do the Americans. This need not be the case however. The Select Committee recommended that the CEGB and SSEB systems should become more integrated in order to use some of the SSEB's massive overcapacity. This would seem a more sensible option than the CEGB's proposal to build a PWR in Northumberland just south of the four AGR's at Torness. The 2GW link with France would further enhance the ability of the CEGB to buy in supplies should plant failure occur.

All in all, this report makes it quite clear that a reduction in the CEGB's planning margin is both possible and desirable. As such it is a mine of facts and figures and to those with a bent for technical debate it will be a boon. This being said it must be pointed out that no end of technical argument will have any effect whatsoever as long as there is a Government committed to ordering nuclear power stations.

The report does, rather belatedly, recognise the fact that "Capacity planning is a matter of some political and economic significance" and urges that it "should not be shielded from public scrutiny and debate." More discussion of this and the effects of such issues as the use of public sector borrowing requirements and recommended return rates within the energy industry would have been welcomed by this reader.

The final sentence of the report makes it clear that 'in no sense is the planning margin a decisive factor' in plant provision — if it were there would be no proposal for another 15 GW of nuclear capacity.

Ian Welsh

Our Lives in their Hands

THE NUCLEAR BARONS. Peter Pringle and James Spigelman. Holt, Rinehart and Winston. $16.95.

The history of nuclear technology now spans more than one human generation. I was born in 1950, five years after Hiroshima, and five days after President Truman approved the construction of the H-bomb: my whole life, and the lives of my peers and their children, have been lived in an atmosphere of fear and fallout. *The Nuclear Barons* takes a detailed look at that history, from the Manhatten Project to Three Mile Island.

The main thread of the narrative documents the development of nuclear weapons and nuclear reactors in the United States, drawing on memoirs of the participants, contemporary sources, and also official papers obtained under the Freedom of Information Act. In parallel with this story, as much as is known about the corresponding events in the USSR is told, and the nuclear adventures and aspirations of the rest of the world are chronicled.

Seen in retrospect, the biggest question that arises in connection with the development of civilian nuclear power is: why did it ever happen? It was an undertaking of enormous engineering complexity and dubious economic benefit, not to mention the attendant health risks. Even in 1953, a report presented to President Eisenhower by a special commission on US natural resources dismissed the importance of nuclear fuels, and concluded: "It is time for agressive research in the whole field of solar energy — an effort in which the United States could make an immense contribution to the welfare of the world."

The answer, on the evidence of Pringle and Spigelman's book, can be traced largely to a small group of powerful and determined men, with a Cold War mentality, a simple notion of Progress, and a belief that splitting the atom, this new US achievement, could provide a tremendous source of prestige in the world. The wish to divert attention from the horror of nuclear holocaust undoubtedly played a part, too: Eisenhower's announcement of the 'Atoms for Peace' programme coincided with his decision to rely exculsively on nuclear arms for national defense. It was followed by a massive publicity campaign, not only in the United States but around the world, which predicted atomic cures for cancer, atomic locomitives, atomic zoos, and generally implanted the idea that things nuclear were new, exciting, and of unlimited promise.

The nuclear establishment would never have been able to achieve its aims without the benefit of freedom from public accountability. Growing out of a military project, it never lost its liking for secrecy. The US Atomic Energy Commission took the view that what the public didn't know wouldn't hurt it. In the 1950s, when H-bombs were being tested above ground in Nevada, the AEC gave no information to local inhabitants on the dates and estimated fallout paths of the tests, nor which tests might be particularly "dirty", nor what precautions could be taken. This information *was* given, however, to Kodak in Rochester, New York, which is on the opposite side of the continent, because photographic emulsion is adversely affected by radiation. At this time, the health hazards of radioactive exposure were known to exist. Exposure standards were enforced for workers in the industry, and for AEC personnel in the vicinity of the Nevada tests; but *no* standards were enforced for the local population, and even monitoring was haphazard.

Twenty-five years later, the same disregard for public safety was evident in the Three Mile Island accident, when the plant operators kept to themselves the knowledge that radiation had been released, and instead assured the press and the public that everything was under control, even though they themselves had no idea what had gone wrong nor what to do about it.

The adoption of nuclear power in the US would certainly not have been so rapid without the financial inducements offered by the reactor manufacturers. Both Westinghouse and General Electric, seeing nuclear power as a way out of their stagnation at the end of the 1950s, offered what were known as 'turnkey' contracts, a cheap package deal in which the supplier took on all the risks and price rises in the course of construction and handed over the completed plant to the purchaser. Even with competition from cheap coal and oil, electrical utilities couldn't resist, and so GE and Westinghouse were able to establish a domestic nuclear industry and an export market, but at a cost: the sales which they made in the three-year period beginning in 1964 lost them around $1 billion in all. Westinghouse also used another ploy: it guaranteed to supply its customers with uranium at a fixed price of 20 dollars a pound for 20 years. When, in 1974, the price of uranium reached 40 dollars a pound, Westinghouse reneged on these contracts, and a company consultant commented: "It is the most stupid performance in the history of American commercial life." (On the subject of uranium, it's a shock to learn that, in the 1950s, the diffusion process for producing fissile uranium from raw ore accounted for *ten per cent* of annual US electricity consumption).

The Nuclear Barons is a valuable source of information on the personalities and institutions, the diplomacy, infighting, technological optimism, technocratic pride, nationalistic fervour, and routine incompetence that have shaped the development of nuclear technology. It stresses the link between civilian and military uses of atomic fission, and concludes by emphasising the need for wisdom in preventing the expansion of electricity-generation programmes and in ending the arms race. As Pringle and Spigelman make plain, the lesson of history is that the nuclear establishment cannot be trusted to act wisely unless compelled to do so; or, in other words, don't despair, *organise!*

Bernard Gilbert

Warm Comfort Farm

HISTORY OF THE FARMSTEAD. The Development of Energy Sources by John Weller. Faber and Faber paperback £5.95.

This very attractive book is about the evolution of the sources of power in agriculture. It traces the changing face of our farm buildings — with a sidelong glance now and then at parallel developments in other parts of the world — through a study of the energy sources which have made them develop in the way they have. Until the Industrial Revolution available sources of the energy needed for the production and storage of food were of two kinds, *natural* — that is wind, water, sun and gravity — and *muscular*, which includes man, oxen, horses, donkeys and, in other countries elephants and camels and so forth. Less obvious, and little in evidence in industrialised countries today, is the use of animal heat as an energy source which used to keep the farmer and his family warm when they and their livestock dossed down cosily under one roof. Farm buildings had massive walls, small doorways, narrow windows and low thatched roofs, all designed to contain the maximum amount of heat. What a lesson in conservation and how far from modern agricultural buildings which are in effect factories, nearly always prefabricated and having no integral connection with the human beings who are employed in them. Increasingly such developments change the look of our countryside — but one must not become sentimental or indeed blind. Errors, injustices, hideous forms of cruelty and agonising poverty were to be encountered behind those narrow windows, and animal proximity took its toll as the source of parasitic infection and chronic ill health. Fortunately much that was good and aesthetically satisfying in the design and layout of earlier farmsteads still exists in our countryside, while estate records provide illuminating insights into both the customs and economics of farming through many centuries. John Weller has made admirable use of these sources of information.

The book is divided into four parts. The first traces the origins and development of farm buildings, from the Longhouse shared by man and beast to the ultra modern steel and concrete palaces we encounter on our rural horizons today. Part two deals with primary and secondary sources of power — primary including the ever fascinating water and wind mills, the use of glass, (those marvellous crystal palaces at Kew and many great estates) and recent developments like plastic film; dykes and dams are described and the ingenious use, particularly in Victorian model farms, of natural hillsides to assist in farmwork. Secondary power sources include all that is generated by the efforts of man and beast which may be directly deployed, as in flailing, or through primitive machinery like the treadmill or the hand driven milking machine illustrated here which, judging by the look of dismay on the cow's face, was probably uncomfortable and inefficient. Many machines were of course horse-driven, and oxen and donkeys played their parts in ploughing, carting and driving the wheels in the great wheelhouses used for a wide range of operations such as thrashing and grinding. In the third part indirect sources of energy on the farm are considered. These include straw, manure, warm air ducts, methane gas and so on, followed in due course by steam which replaced many of the primary and secondary sources already mentioned. This section carries the survey on to diesel engines and electronics including the most up-to-date (and to an old fashioned milkmaid like this reviewer the ultimately abhorrent) system whereby Buttercup the old dairy cow has been reduced to no more than a numbered part in a milk-production factory.

In the final part of his very readable account, John Weller discusses the materials and structure of farm buildings as they have progressed inevitably away from the marvellously satisfying vernacular of local stone and slate or flint, wattle-and-daub, reed and straw to the horrors of battery houses, pig crates and the landscape-destroying acres of concrete and galvanised steel of feedlots.

Full of clearly written information and copiously illustrated with photographs, reproductions of old drawings and plans of architect-designed model farm complexes from the rich heyday of English agriculture in the nineteenth century this book is, I am sure, a must for anyone interested in our agricultural and architectural heritage.

Ruth Lumley-Smith

The Love Canal Story

LAYING WASTE by Michael Brown, Pantheon Books. £10.95. Available from Scientific and Industrial Studies, Norwich House, 11-13 Norwich Street, London EC4.

Opinions differ about the merits of allowing an investigative journalist to report on a technical or environmental matter. Some say that the scientific aspects are not likely to be understood and that the element of irresponsible sensationalism is all that is needed to generate high sales. Others point accusingly to officialdom and argue that the tone of authoritative reports amounts to conspiracy or cover-up and that only the free press can be relied upon to ferret out the major environmental issues.

Whatever view you hold you are likely to welcome Michael Brown's new book *Laying Waste.* Michael Brown was a reporter for the *Niagara Gazette* and was responsible for piecing together the unpalatable truths of America's Love Canal — the chemical waste dump in Niagara City, New York, which leaked poisonous chemicals over a 30 year period and caused nervous disorders, rashes, headaches, breathing difficulties, ear infections, seizures and nausea among people living nearby. Although early complaints from residents were ignored by the health authorities, subsequent tests showed that more than 80 hazardous compounds were discovered on the dump and at least 10 of them were known carcinogens: many affected the brain and central nervous system and some caused narcosis and anesthesia. As public pressure grew an official health survey showed a high rate of miscarriages and abnormally high birth defect problems. In one female age group, 35.3 per cent had records of spontaneous abortion. The State's epidemiologist confirmed liver damage and hepatitis-like symptoms. A battle raged between a chemical company and a local authority about the legal liability for the damage. Meanwhile the toxic residuals continued to leach through the ground into the homes of local residents, many of whom were actually employed by the chemical company in question. No-one knew how to combat the pollution.

Eventually President Jimmy Carter declared the dumpsite a national emergency thereby releasing federal funds to pay for the permanent abandonment of 240 homes and the mass evacuation of the 237 families. Eight feet wire fences were erected around the contamination zone and a new school was permanently closed. But even then the migration of toxic chemicals continued underground as water-borne pollutants leached into more homes another block away. A further 25 families had to be rehoused.

The contaminants were organic solvents and chlorinated hydrocarbons and traces of dioxin, (the vicious killer released in the Seveso tragedy in Italy) were eventually detected as the identified leaking chemicals topped 200. The psychological pressures on families concerned about environmental health on the one hand and jobs and real estate mortages on the other resulted in a high incidence of divorce. In monetary terms the total cost is not yet quantified but 15 million dollars have already been spent on cleaning the area, 2.25 million dollars on rehousing residents and lawsuits of 500 million dollars are still in the offing.

Yet Love Canal is by no means the only waste chemical legacy to be found in the U.S.A. Michael Brown reports on the despoilation of Bloody Run Creek where pesticides migrated from a waste landfill site into a surface stream. From a landfill accepting pharmaceutical wastes in Charles City, Iowa, traces of chemical pollutants were found to be migrating a distance of 50 miles into drinking water wells. At Trenton, New Jersey, as many as 3.5 million people may be affected by subterranean migration of pollutants from more than 100 landfills, pits and lagoons. One report states that between 10 and 15 of the states public water systems were closed in a 5 year period due to poisoning. In Jackson Township, Ocean County, more than 100 water wells had to be closed due to contamination.

Devils Swamp, Louisiana: Stringfellow Quarry at Riverside, California: Hemlock in Michigan: Lowell, Massachusetts: Brooks, Kentucky: are among the chemical dumps cited for spilling their wastes into the environment. The list is seemingly endless and the total cost of cleaning up the legacy quite beyond imagination.

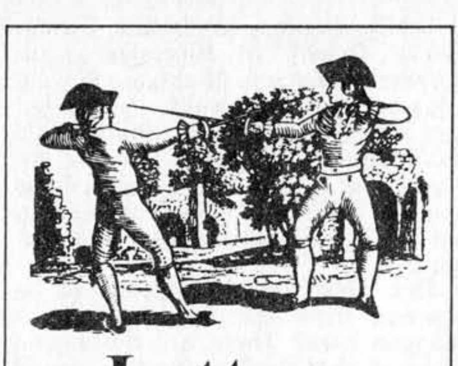
But what are the lessons to be learned from this saga? Could it happen here? There are those who contend that similar situations could not occur here because our rules and regulations protect us. Yet others can point to uncontrolled releases from British landfill sites and remind us that chemicals have no respect for the laws of parliament.

Recently the House of Lords Select Committee on Science and Technology has examined toxic waste disposal in Britain and called for changes and improvements. Elsewhere, at various locations throughout the country local debates are continuing about acceptable and unacceptable methods of disposing of chemical wastes. It is a huge problem and those concerned with it must not miss the opportunity to read Michael Brown's report — if only to recognise the essential issues of this urgent matter. Those who do read this book will have no difficulty in understanding why it won three Pulitzer Prize nominations and a special award from the U.S. Environmental Protection Agency.

Brian Cope

Erratum

We apologise to Leslie Freeman for referring to her as *him* in the review of *Nuclear Witnesses Insiders Speak Out (The Ecologist,* Vol 11, No. 6) and to the author of the review, Bernard Gilbert. This was due to an error on our part which we much regret. We also apologise for a printer's error in the same review, 1st col. last para, line 25, 1st word which should read *teenagers* not transfers.



Letters

Dear Sir,

As a professionally qualified ecologist and an author of "Shaping Tomorrow" I feel that I cannot let your editorial "Rationalising the Impossible" pass unchallenged.

As you are no doubt aware, your "good men of Harwell" (and, I must add, a good many others) devoted many weekends and evenings to study and debate these issues together, before they even began the enormous task of writing and editing the final document. Indeed the complexity of the subject of ethics in a technologically advanced society is so great that I honestly doubt whether my answering your specific criticisms of "Shaping Tomorrow" one by one in a letter could actually serve any useful purpose. It would simply open up an inconclusive and unsatisfactory intellectual jousting match. Rather, I wish to comment upon the spirit of your criticisms.

I was disappointed to find that your assessment of "Shaping Tomorrow" contained so little by way of constructive criticism and so much apparently sneering cynicism. The authors of "Shaping Tomorrow" nowhere claim that the fruit of their studies and discussions is a wholly definitive and infallible document. Undoubtedly "Shaping Tomorrow" is not perfect, but I would submit that as a sincere attempt to assist the man-in-the-street and the man-in-the-pew to consider the dilemmas posed by technological developments and to arrive at his own judgements "Shaping Tomorrow" deserves a better balanced and less cynical press than that afforded by it "The Ecologist".

Why is it that journalists and even scientific journalists so often seem to ignore totally all that is good, worthy and constructive in a report, but make such play of those aspects with which they themselves find fault? If "The Ecologist" is to retain its scientific integrity and any reputation as a balanced journal I believe it could, and should do better than to resort to the methods of the sensationalist tabloid press.

Finally, I would like to point out that in its 72 pages "Shaping Tomorrow" does discuss a good deal more than nuclear power, including such issues as factory farming, human cloning, genetic engineering, energy and material resources, computers, personal privacy, unemployment, and their relationship to the Christian faith.

Yours faithfully,
Dr. P. Little, M.I.Biol.
Reading, Berks.

Sir,

The review of 'Shaping Tomorrow' by Nicholas Hildyard (Ecologist *Vol. 11/5 pp 202-203) has been brought to my attention. As the editor of two chapters of 'Shaping Tomorrow' I request the courtesy of being allowed a reply. I confess, however, that a misleading diatribe does not easily allow a reasoned response.*

An amusing, but phoney, antithesis in the form of an adage does not, for me, represent an oracle of truth, so I will disregard (as being irrelevant) the remarks on the 'rational' versus 'rationalising' and all other evidence of the substitution of polemics for reason and innuendo for good manners.

I concede that there is an element of truth in Hildyard's accusation that some of the biblical citations are not entirely relevant when restored to their contexts. In no case, however, are these citations necessary to the argument. Besides the criticism is curious in view of his own idiosyncratic selection of quotations from 'Shaping Tomorrow' in a manner verging on the deliberately perverse.

Hildyard's failure (inability?) to discriminate between knowledge, interpretation and values does not aid understanding of his meaning(s).

In 'Shaping Tomorrow' our method was to review the relevant facts as honestly as we could and then draw conclusions under the influence of values derived from our perception of the gospel of Christ.

Hildyard is entitled to seek his values in some other system of reference. I find his philosophically-indefensible pantheism peculiarly offensive myself. When I was afflicted with cerebral malaria I would not have taken kindly to the suggestion that the parasites in my brain were a manifestation of God.

If Hildyard considers we have overlooked relevant facts than it would have been more rational of him to have drawn our attention to these. Regrettably, however, his emotive style of review suggests he has no stomach for reasoned debate.

Yours faithfully,
R.H.L. Disney,
Malham Tarn Field Centre,
Settle, Yorks.

Dear Sir,

Very many thanks for sending me a copy of "Nuclear Energy: the real costs".

It is a very impressive analysis, and will need some fast-thinking by the CEGB.

Is the nuclear programme entirely driven by industrial pressures? The "plutonium credit" if considered as alternative to uranium for power may not be attractive (or even feasible), but its military value (i.e. high Pu-239 material) could be anything. But the considerable stocks of magnox fuel—which is much better than PWR—apart from evident problems in reprocessing oxide fuel—make little sense of a future PWR programme.

In any case with laser separation of Pu239/Pu240 any past spent fuel is a source of high-grade 239.

If this credit is not there who is *pushing the Department of Energy, e.g. in the context of energy conservation programmes, etc., which are much cheaper and are probably the only ones which can replace in time available an appreciable part of the 70% of our energy we now get from oil/gas.*

It will be interesting to see how CEGB/Department of Energy etc. respond. Perhaps they won't! I expect you have sent copies to the relevant MPs.

Yours sincerely,
Martin Ryle,
Cavendish Laboratory,
Cambridge.

Classified

MISCELLANEOUS

SUPPORT THE ECOLOGY PARTY, Britain's fast-growing green party.
We need your involvement and your ideas. Write for details to: The Ecology Party, 36/38 Clapham Rd., London SW9 0JQ. Tel: 01-735 2485.

BELVEDERE PRESS publish your book privately, highest standards, manuscripts invited, all subjects including special interest topics. Ref. EC., Box No. 6, Liskeard, Cornwall. PL14 6AA.

KITES—Amazing variety, 150 colourful designs, 30 page illustrated catalogue. FLY MALVERN KITES, St. Ann's Well, Great Malvern, Worcs. (65504).

Use artificial lighting and **let it pay for itself.** Grow sun loving crops rapidly, even in winter, with a SUNLIGHTER system in your greenhouse to supply the extra light needed. Water melons, cucumbers, tomatoes, **anything** will thrive.
A SUNLIGHTER is powerful enough to grow plants from seed to maturity in the total absence of natural light.
The SUNLIGHTER range also includes attractive systems for the home.
Plan ahead. Summer won't be here for long.

for free details write to: SUNLIGHT SYSTEMS, 120 ACRE LANE, LONDON SW2 5RA.

Name ....

Address ....

....

PUBLICATIONS

NUCLEAR FRAGMENTS, an anthology of poetry, prose and pictures. £1.95, including a donation to C.N.D. and A.N.C. From: Earthright Publications, 7 Blayney Row, Newcastle Upon Tyne, NE15 8QD.

SUNPOWER BOOKSHOP for Ecology/Nuclear/Power and Arms/Self-Sufficiency. Send S.A.E. for mail-order list. 83 Blackstock Road, London N4 2JW. Phone 01-226 1799.

SITUATIONS VACANT

OWING TO PREGNANCY, for which we claim no responsibility, our mainstay person is leaving. We therefore have an INTERESTING POSITION for an intelligent person with commitment to the ideal that "Small is Beautiful". Gross pay £1.80 per hour. Exact hours negotiable. One Saturday in three working. Please write, enclosing c.v. (no initial calls, please) to Self-Sufficiency and Smallholding Supplies, The Old Palace, Priory Road, Wells, Somerset.

CONFERENCES & COURSES

WEEKEND CONFERENCE on Biodynamic gardening at Chelwood Gate, Sussex, June 4th-6th. For details (S.A.E.) B.D.A.A., Woodman Lane, Clent, Stourbridge. DY9 9PX.

THIRD ECO-PHILOSOPHY CONFERENCE at DARTINGTON. 9-11 July. Theme: Preparing for the 21st Century. Philosophy in a new setting, with an accent on the ecological, the holistic, the connected — one which is relevant to our daily economic and practical strivings. Details from: Henryk Skolimowski, Elmhirst Centre, Dartington Hall, Totnes, Devon.

OXFORD. Exceptional, personable attractive widow. 40's, travelled, of some standing, seeks tall soulmate/widower of similar ilk for mutual happiness. Box No. 146.

HOLIDAYS

"THE PYRENEAN HIKER", Active holidays in the West Pyrenees for persons interested in mountains, rambling and the natural sciences. For 1982 brochure send S.A.E. to P.O. Box 39, Leigh, Lancashire, England.

PEACE AND QUIET and natural foods on your holidays in France. Apartments for rent in Montmoreau, 30km from Ribérac (Dordogne). Tou Naou, 4, route des Mirandes, 16190 Montmoreau, France. Tel :010-3345602453.

BEAUTIFULLY converted, mediaeval, self-catering cottages on trout farm. Riding, tennis, fishing. Ask for brochures from Dan Parsons, Worthyvale Manor Farm, Camelford, Cornwall, UK. (Tel: 0840-212375)

DO YOU CARE?

Join the International Ecologism Political Party. Contact: Ecologism Party, 1330 S.E. Bristol No. 14, Santa Ana,CA.92707. Platform Info. $3.00.

CLASSIFIED ADVERTISEMENTS MUST BE PREPAID.

To: The Ecologist Advertisement Dept., Worthyvale Manor Farm, Camelford, Cornwall, PL32 9TT.
Please insert the following advertisement in the next .... issues.
Cheque/P.O. to *The Ecologist* enclosed.
(Word rate 15p per word. Minimum charge £3.00. Box No. £1.00)

Name: (Block letters please) ....

Address: ....

Date: .... Signed: ....