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FEATURE ARTICLE

Environmental standards – new procedures for new paradigms

By Professor Richard Macrory

Early environmental legislation

The genesis for the Royal Commission's concern with environmental standards can be traced back to its earlier studies, and especially those concerning Freshwater Quality (1992) and Incineration of Waste (1993). In both those areas we were aware of the extent to which contemporary legal controls were now guided by environmental standards of various sorts, often expressed in scientific terms and numerate form which were legally binding. To a large degree the immediate source of such standards in this country was found in European Community law, yet the actual origin and rationale for the numbers that emerged was often obscured. We were equally aware of the large degree of scientific uncertainty that exists, especially in the field of environmental toxicology which often provides the basis for such standards. To take one extreme example, dioxin has been shown to be five thousand times more lethal to hamsters than to guinea-pigs. There appears to be no convincing explanation for such a difference in species susceptibility, and more importantly we do not know whether humans are more like guinea pigs or hamsters in this context.

These examples suggested that a wider investigation of the subject was needed. The Commission's study occurred at a time when issues such as Brent Spar, the BSE crisis, and the continuing debate over genetically modified organisms (GMOs) suggested a deeper malaise in current systems of environmental control, and a public unease with current regulatory systems. Certainly some of those submitting evidence to the Commission, including official bodies, clearly hoped that the Commission would produce some sort of fool-proof methodology for making environmental standards – a 'black box' which would resolve current uncertainties and resecure public confidence.

Public confidence

It became clear during the investigation that this would be an illusory goal. Nevertheless, what we have attempted to do is to explain clearly reasons for current difficulties, and to propose a set of principles which would form a sounder basis for the

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standard-setting procedures. We were concerned at the extent to which recent opinion polls and contemporary research suggested a lack of confidence in governmental bodies concerned with environmental science and standard setting, and a central theme of the report is to consider how such bodies (and here I would include Parliament) can establish better public trust in this highly complex and fast-moving field.

A traditional response has been to extend rights of public consultation where potentially controversial public decisions are being made. In the environmental field, legal rights of consultation in this country have largely been associated with land-use planning controls. Similar rights were extended during the 1970s and 1980s to other fields of pollution control, for example to where licence applications for effluent discharges to water were being made. Yet the picture is distinctly asymmetrical. We have no general legal principle or developed procedures concerning public rights to comment on proposed standards equivalent to those found in the United States. Equally significant, we recognised that whatever form of consultation took place, it was often extremely important to ensure that systems were sufficiently flexible to allow for earlier consultation on the breadth of issues of public concern rather than to impose potentially over-restrictive prior constraints. This was one of the lessons of the Brent Spar episode. Similarly, extending rights of public consultation concerning releases of GMOs (as is the aim of current EC proposals) may not secure public confidence if consultation does not encompass issues on which there is genuine public concern. Applying such principles requires considerable political sensitivity and judgment.

Consultation

Yet traditional forms of consultation, though important, are insufficient in themselves. Another connecting theme for securing better public confidence was the need for bodies setting environmental standards to operate in an open and transparent way By transparency we meant that there must be full publicity for their existence, their terms of reference, the decisions that they take, and the reasons for taking them. The presentation of the various types of technical analysis that form an input into environmental standard setting, be they scientific, economic, technological, or social, should clearly state the assumptions and limitations of the analyses, and these should be publicly available. New information technology, and especially the Internet, has provided extensive opportunities for providing greater administrative transparency – at a cost but not an excessive one. To be fair, many British official environmental bodies, such as the Countryside Commission and the Environmental Agencies, have made considerable efforts in this area in recent years. Even the Royal Commission is not immune – the minutes of its monthly meetings are now on its Web site, and for those interested in how thinking on a difficult and complex report develops the information provides an intriguing account.

Perhaps the most challenging aspect of the report concerns the question of public values. We were convinced that many environmental standards could not be solely derived from technical or scientific analyses, important as they are and will remain. Values or ethical principles – why we wish to protect the environment or certain aspects of it – underlie many if not all environmental standards. Politicians, of course, to a certain extent have a responsibility to reflect public values, and the report contains a detailed examination of the current role of Parliament bodies (both European and national) in the standard setting process. But we were doubtful whether current procedures provided sufficiently effective means for discerning the true nature and content of such values. Values in this sense are not the same as opinions, and we were concerned whether various techniques developed, especially in the field of environmental economics, were appropriate for discerning values in this sense. Such values are not necessarily well formed or pre-fixed but emerge from discussion and debate, and traditional forms of consultation, though providing valuable insights, are not generally an adequate method for their articulation.

Determining public values

The Commission's report therefore explored various new procedures being developed in this country and elsewhere which attempt to explore the nature of public values. Unfortunately the terms currently in vogue often fail to reflect the rationale underlying our analysis. 'Stakeholder meetings' generally involved direct interests rather than the general public, and are not designed to explore underlying values. 'Consensus conferences' imply a meeting of minds which may simply not be present, while 'Citizen's juries' may suggest that members of the public are acting as the final arbitrator. We are clear in our own minds that the final decision on standards is a political one, to be taken by a politically accountable body or individual. The purpose of new methods of exploring public values is not to diminish that responsibility but to provide the political decision-maker with a better insight of the nature of such values. Nor do we advocate a rejection of expert analysis, scientific, economic and technological, which will continue to form a vital input to the final decision but one that needs to be tempered by a greater sensitivity to the nature of environmental values.

Setting Environmental Standards is a report which we hope will be read by all of those involved in environmental decision-making, especially at a political level. It does not provide for simplistic solutions, but promotes a clearer understanding of the nature and purpose of environmental standards, and the reasons for some of the current confusion and unease. The principles that we advocate are intended to provide a more robust basis for setting standards, and one more attuned to the needs of civic society in the 21st century.

■ Summary of an address for the Parliamentary and Scientific Committee as published in *Science in Parliament*, Vol 56 No 2, and reproduced by kind permission of the publishers.

The Hon. Secretary's news desk...

Holiday season

The July/August edition of the Journal is always a difficult exercise as the preparation period falls in the height of the holiday season. My news items are, as a result, somewhat limited since this year I am enjoying a rather more extended break than usual.

A 'recharging of batteries' is not inappropriate since we are envisaging a very busy forward programme. In addition to our EAF grant aided project (see last Journal) and an increasingly active course accreditation schedule we have plans for a members' conference in 2000, a complete revision of the Careers Handbook and, of course, our annual Burntwood Memorial Lecture.

Government response

Immediately prior to the holidays one further response has been prepared and submitted:

■ *Modernising planning: streamlining the processing of major projects through the planning system*, to the DETR, prepared by Jim Whelan.

Rolex awards

Every year the Institution receives details of the Rolex Awards for Enterprise, which cover, amongst other areas, environmental projects. These are substantial awards and may be of interest to members. The general text of the letter giving details of the awards is reproduced below.

The lead-in time for applications is very long and the deadline for 2000 is already past. We should be looking now to preparing project proposals for an application next year for the start of 2001.

We have advertised the awards before but have not heard news of any member applying. If you should apply, please do let me know.

The Rolex Awards for Enterprise

In the summer 1999 edition of *The Rolex Awards for Enterprise (RAE) Journal*, along with regular features which cover updates on past winners of the Awards, news on how to apply, and the selection process for the Awards, there are some articles which we would specifically like to draw to your attention.

For example, we learn about Les Stocker, an English accountant-turned-animal saviour, who set up Britain's first wildlife teaching hospital, St Tiggywinkle's, where no creature is turned away; and British archaeologist, Georgina Herrmann, who is leading an international team of experts in Turkmenistan to unearth the secrets of Merv – three cities built between the 6th century BC and the 13th century AD in the middle of the Kara Kum desert.

As you may be aware, the RAE were created in 1976 to provide outstanding individuals with the support and recognition they need to turn innovative ideas into practical working projects. The awards are unique in supporting new concepts and on-going projects, unlike other prize schemes that reward past achievements.

Applications may be submitted by anyone of any country and age in the areas of science and a medicine; technology and innovation; exploration and discovery; the environment; and cultural heritage.

If you would like to receive further information about any of the individuals covered in the Journal, or to learn more about the awards themselves, please contact me, or my colleague, Rebecca Gudgeon on 0171 878 3000.

Kate Angus
on behalf of the
Rolex Awards for Enterprise.

IES postal address

Members are still addressing correspondence to 14 Princes Gate, London (*this address is no longer valid for the IES*) despite the continuing advertisement of our new postal address at:

PO Box 16,
Bourne,
PE10 9FB

PLEASE make a note of the change, as very shortly mail sent to the old address will ***not*** be forwarded or re-directed.

RAF

New members

The IES is pleased to welcome the following to membership of the Institution:

Mr A.D. Black	Graduate Manchester Metropolitan University
Mr T.P. Brady	Sales Director Dee Environmental Services Ltd
Mr P.N. Carruthers	Contract Manager British Nuclear Fuels plc
Mr M.J. Cullis	Senior Lecturer Swansea Institute of HE
Miss L.J. Elliott	Graduate Chemist, British Energy – Sizewell B Power Station
Mr P.M. Harvey	Environmental Geochemist IKM Consulting Ltd
Miss G.W. Hinde	Postgraduate Student Cranfield University
Mr B.J. Marshall	Student, University of Plymouth
Mr L.A. Mélin	Senior Planner Essex County Council Planning Dept
Mr Ming Leong Kalvin Lau	Technical Officer Tate's Cairn Tunnel Company Ltd Hong Kong
Mr S.C. Moreton	Process Technician, Severn Trent Water
Mr P.F. Thair	Director, DPDS Consulting Group

Forthcoming events, courses and conferences

6-8 September 1999
International Conference on Emissions Monitoring
University of Warwick.
Announcement & call for papers.
Will cover legislation, stack and ambient measurement techniques, calibration, air quality and case studies.
Details: Dave Curtis,
Source Testing Association
Fax 01462 457 157
e-mail CEM99@-t-a.org

6-10 September 1999
Monitoring for Nature Conservation
Snowdonia National Park Study Centre, Plas Tan y Bwlch.
Short course to further knowledge and skills necessary for the effective monitoring and management of sites of nature conservation interest.
Details: Dewi Jones,
Plas Tan y Bwlch, Maentwrog,
Blaenau Ffestiniog,
Gwenedd, LL41 3YU
Tel: 01766 590 324
e-mail:
plastanybwlch@compuserve.com

13-15 September 1999
(also 22-24 March 2000)
Working with your stakeholders – resolving conflict and building consensus on environmental issues,
Wast Hills House, Birmingham
£445-845
3-day management development course in process design and facilitation skills.
Details: Matthew Stubbings,
The Environment Council,
212 High Holborn,
London WC1V 7VW
Tel: 0171 632 0103
e-mail: matthews@envcouncil.org.uk

14-15 September 1999
5th National Conference on waste
La Baule. Conference covering the French approach to waste management, workshop sessions including waste reduction, land disposal, low level radioactive waste.
Details: Secretariat General des Assises
DRIRE de Pays de la Loire,
2 rue Alfred Kastler,
PO Box 30723, 44307 NANTES
cedex 3 France
Tel: (33) 02 51 85 80 99
Fax (33) 02 51 85 80 44
e-mail: Assises.Dechets@cmn.fr

21-22 September 1999
The future of waste management & minimisation
Regents College, London
£399-699
Conference covering future of waste management policies, waste and planning, landfill tax credits, recycling.
Details: IBC UK Conference Ltd,
Gilmoora House,
57-61 Mortimer Street,
London W1N 8JX
Tel: 0171 453 5496
e-mail: cust.serv@ibcuk.co.uk

22-23 September 1999
Coastal Management 1999
Grand Thistle Hotel, Bristol
£395
Conference covering coastal management issues.
Details: Ms Liane Otten, Thomas Telford Conferences,
1 Great George Street,
London SW1P 3AA
Tel: 0171 665 2313

23 September 1999
Protecting environmental quality and human health – strategies for harmonisation
University of Leicester
£89
One day seminar exploring ways in which a diverse range of disciplines, interests and sectors can be integrated to inform policy and decision making to reduce risks to the environment and health.
Details: Seminar Administrator,
Institute for Environment and Health,
University of Leicester,
94 Regent Road,
Leicester LE1 7DD
Tel: 0116 223 1617

20th October 1999
EMF '99
– the UK's largest environmental management event
Olympia 2, London
Free national exhibition, featuring the UK's leading accreditation bodies, consultancies and software suppliers – all at one event, in one activity packed day. Call for *free* tickets.
Plus, optional seminars covering: the future of environmental consultancy, environmental information on the internet, sustainable development legislation alert, GIS, and environmental management. Exclusive discounts for IES members. Early booking advised. Please ask for details.
Details: Information for Industry,
4 Valentine Place,
London SE1 8RB
Tel: 0171 654 7199
Fax: 0171 654 7171
e-mail: emf@ifi.co.uk

25-28 October 1999
Environmental Protection 99
Brighton Conference Centre
Exhibition and conference covering air pollution, energy, waste, contaminated lands and noises.
Details: Peter Mitchell, NSCA
Tel: 01273 326 313
e-mail: admin@nsca.org.uk

7-27 November 1999
A sense of wilderness
Schumacher College, Dartington, Totnes, Devon
£1,350
Short course looking at wilderness significance and conservation.
Details: Schumacker College,
The Old Postern, Dartington,
Totnes, TQ9 6EA
Tel: 01803 865 934
e-mail schumcoll@gn.apc.org

5-9 June 2000
Healthy environments – the local challenge
Oslo, Norway
Call for papers. Conference covers local communities' involvement in developing healthy environments
Details: PLUS Convention Norway
A/S, PO Box 1646 Vika, N-0119 Oslo
Tel: 47 67 56 90 12
e-mail chaskim@online.no

Compiled by David Holmes

OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic

Further protection for the North-East Atlantic

Comprehensive environmental goals for the offshore oil and gas industry, together with the controls and management systems to deliver them, are the aim of a new 25-year strategy adopted by the OSPAR Commission for the Protection of the Marine Environment of the North East Atlantic, meeting in Hull, England.

The OSPAR Commission brings together Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the European Commission (representing the European Community). Observers from 22 non-governmental organisations, representing environmental groups and industry, also contribute to the Commission's work.

With this fifth strategy, alongside the four strategies on hazardous substances, radioactive substances, eutrophication and the protection of marine ecosystems adopted at the Ministerial meeting of the Commission last year in Sintra, Portugal, the Commission completed the overhaul of its policies to give effect to the consolidated and up-dated international convention under which it works and which entered into force last year.

The fifteen countries, together with the European Community, also agreed to intensify their efforts to identify and take the necessary action for achieving further substantial reductions, or the elimination, of discharges, emissions and losses of radioactive substances by 2020.

The Commission also adopted guidelines on controls on creating artificial reefs for encouraging marine wildlife and a recommendation on the best available techniques to be applied in the production of emulsion PVC, thus completing its coverage of the PVC industry. It also reviewed its methods of work, to help effective implementation of the five long-term strategies and effective follow-up to the Quality Status Report on the whole of the North-East Atlantic to be published in the year 2000. This report will be a first for coverage and detail in reviewing an ocean.

■ *Further information is available from: www.ospar.org.*
OSPAR Secretariat telephone number: 0171 242 9927.

The future of environmental consultancy

This is the title for a seminar to be held on 20 October at EMF'99 at Olympia 2 London (see Events, page 4).

The impressive line-up of speakers and chairman makes attendance at this seminar ideal for those looking to make their future in consultancy, those who rely on consultants' advice, and all who expect to be in this business in ten years' time.

Robin Bidwell, CEO of Environmental Resources International, is clear in his view on how liability, regulation and influence of sustainable development on product strategies will create enormous opportunities… and the need to offer authoritative advice from Manchester to Mongolia.

Alan Hearne is Chief Executive of the RPS Group and led its admission to full listing on the London Stock Exchange. He will look at consultancies as a business, their ability to grow revenue and enhance earnings… and ask whether there is any prospect for an independent future.

Stephen Creed, MD of Stanger Science & Environment (part of Tarmac plc), will look forward 10-15 years. He will pick up on the key drivers of population growth, global corporations, government policy and work practices, and examine their impact on the NGOs, consultants and business.

Sir Anthony Cleaver will chair this important seminar. In addition to his role as non-executive Chairman of AEA Technology, Sir Anthony heads the influential Advisory Committee on Business and the Environment.

IES have negotiated an exclusive, £20 discount for members – making the total cost just £79 + VAT.

■ *For details, call Steven Brimble on 0171 654 7199.*

Energy and the environmental geochemistry of fossil, nuclear and renewable resources

Edited by Dr Keith Nicholson, Robert Gordon University

IES members can purchase this book at almost half price for their personal use only. Institution and library price is £75.

Contents and ordering details can be found at http:/www.thistlepress.freeserve.co.uk/macaci/

THE INSTITUTION OF ENVIRONMENTAL SCIENCES

PROFESSIONAL INDEMNITY SCHEME

As you are aware, all responsible professionals giving advice should insure themselves against claims for professional negligence. In the last few years the courts have held that professionals owe a duty of care not only to those for whom they perform services, but also to any other party who foreseeably relies on their advice.

There are many Professional Indemnity policies on the market that will provide you with the basic cover required but there is only one in place that is formally recognised by the Institution of Environmental Sciences as having the breadth of cover, and the specifications, that make it totally compatible for people in your profession.

We have worked in conjunction with the institution and insurers to design a policy specifically for your needs, with an underwriter who specialises in environmental sciences.

Our Professional Indemnity policy will cover you for the following:

- Claims made against you by third parties, alleging negligence during the policy period and reported to Underwriters during the policy period, up to a total limit of £1,000,000 (including defence costs and expenses).
- Costs and expenses incurred in replacing or restoring lost or damaged documents, up to a limit of £250,000.
- Duplicate documents, training material and course notes.
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Future challenges for environmental policies

Professor Sir Tom Blundell FRS, Chairman, Royal Commission on Environmental Pollution

The 21st report of the Royal Commission on Environmental Pollution, entitled Setting Environmental Standards, focuses on public acceptance of environmental policies. People must have confidence in the way they are protected against risks. That is best achieved if they are involved at every stage. Controversies over the last few years show clearly that governments, industry, the public and scientists all need a much better understanding of the relationship between policies, science and values.

The nature of environmental concerns has changed

At one time dealing with pollution was largely a matter of dealing with local pollution of water or air. The effects were obvious, and so generally was the cause.

> ***There is accumulating evidence that a lack of understanding of what constitutes sound science is influencing public perceptions… A recent study showed there was a tendency for the [nuclear] industry to undermine its credibility by giving the impression of comprehensive certainty and control***

The effects of human activities on the environment of most concern are much broader in scope, less obvious and much more complex. Some of them, such as global warming or destruction of stratospheric ozone, are global in scale. Many pollutants are carried over very long distances, and may become concentrated or change their form. Concern about the impact of pollution on human health now often relates to chronic effects occurring a long time after initial exposure. Understanding public values is essential when addressing environmental problems.

The Royal Commission recommended that assessments should be carried out on the smallest geographical area. But if the data are global, or we need to have a uniformity of standards for political reasons, there are naturally inbuilt tensions in the system. This, I think, is one of the key issues in setting standards in the modern world.

Scientific assessment and scientific uncertainty

We cannot be sure that the assumption that policies designed to protect human health would be sufficient to protect the natural environment. The aim of scientific assessments is to answer three questions:

1. How intrinsically hazardous is a substance in terms of effects on human health?
2. How intrinsically hazardous is the substance in terms of effects on the natural environment?
3. How does the substance move through the environment, and what levels of exposure to it are likely to occur?

However, scientific assessments in complex areas concerning the environment are often uncertain. BSE is one of the clearest examples of the uncertain basis of our knowledge where important national decisions were said to have been based on science. But the science was uncertain and this uncertainty was never properly communicated to the public.

The uncertain basis of science is not widely understood; the popular image is of the scientist as an expert who can reveal truths that are unassailable and unalterable.

The Royal Commission's investigations did not give any reason to think that the risks from pollution are either overestimated or underestimated. However, the lack of understanding of uncertainty in science and of the need for a precautionary approach tends to reinforce perceptions that environmental regulation is too stringent.

What is sound science in environmental policy making?

At each stage of a scientific assessment, there are bound to be limitations and uncertainties associated with the data. The procedures used to set environmental standards must recognise this. Indeed the requirement for sound science is not a requirement for absolute knowledge.

When considering the process of scientific assessment and its output, two separate issues need to be addressed. First, is it good science? Is the science well done? Are the uncertainties and limitations in the data properly recognised? And are the assumptions made explicit?

Second, is it useful science? Does it provide a firm basis for policy decisions? In many cases the very best possible scientific assessment will contain many uncertainties. Where these cannot be resolved in a reasonable time it is the policy-maker's responsibility to take a decision in the face of uncertainty.

There is accumulating evidence that a lack of understanding of what constitutes sound science is influencing public perceptions. For example, a recent study on the nuclear industry in West Cumbria showed that there was a tendency for the

Clearly any process must be comprehensive and comprehensible. The first stage is to recognise that there is a problem and to define it…

industry to undermine its credibility with local people by its insistence on giving the impression of comprehensive certainty and control.

This leads to a vicious circle. The industry and regulatory authorities believe that the public will be confused about uncertainty and so give absolute assurances. This defensive approach makes it difficult to acknowledge incidents and this in turn undermines outsiders' confidence. Attempts to recover confidence by making more definite assertions of complete control further undermine the confidence of the local population.

The output of a scientific assessment

These observations emphasise that a scientific assessment should not be presented as a single option or statement; this may give a spurious impression of accuracy. Rather it should present the range of possible interpretations of the available evidence, or the range of scientific possibilities and options concerning a particular course of action, accompanied by acknowledgment of the assumptions and uncertainties implicit in the assessment.

One very thoughtful approach is the NUSAP (Numeral – Unit – Spread Assessment – Pedigree) notational scheme. This scheme includes both quantitative and qualitative items of information. Thus we move progressively from a number expressing magnitude, to a measure of the spread of the data, then to an assessment of the reliability or otherwise of the quantitative information, to the Pedigree which describes uncertainties that operate at a deeper level and so to an evaluative account of the production process of the qualitative information.

Technological basis of environmental standards

Every decision must take into account an assessment of the technological options. How should these options be evaluated in terms of their implications for the environment?

The Royal Commission's report on Setting Environmental Standards concluded that this can best be done on the basis of life cycle assessments. Looking at the whole life of a particular product directs attention to the points at which intervention to protect the environment will be most effective. The aim of assessments of technological options should be to widen the range of options considered, including those that involve technology forcing. At the same time, broadly based assessments of options on a life cycle basis must not be allowed to become an excuse for avoiding or delaying significant improvements available at particular stages in the cycle.

Bringing together scientific and technological assessments with a consideration of economics and people's values

How should the different elements be brought together, so as to ensure there will be a more robust basis for environmental standards and reaching decisions about environmental policies?

Clearly any process must be comprehensive and comprehensible.

The first stage is to recognise that there is a problem and to define it. The broad policy aims for dealing with that problem must be then established. Although these have hitherto been relatively technocratic parts of the procedure, it is important to emphasise that people's values must be taken into account from the earliest stages of defining the problem and framing the questions that need to be addressed.

This process must recognise that assessments and analyses of technology, economics and risk, must inform policy decisions, but cannot pre-empt them…

The second stage is the analysis. We must evaluate the effectiveness of existing policies and further scientific research. What happens at this stage is of fundamental importance in determining what will be regarded as relevant to the eventual decision and what analyses and investigations will be carried out. The Brent Spar episode provides a classic example. The issue was at first conceived too narrowly as simply finding the best way to dispose of one oil platform. Eventually Shell and the government were forced to see it in a much broader perspective.

The Royal Commission emphasised the close relationship of the scientific, risk, technological, economic and public value evaluations. The emphasis put on each component, and the time and resources devoted to it, will vary according to the nature of the issue under consideration, and the reliability and comprehensiveness of the information already available. All the experts involved in carrying out analyses should have their affiliations recorded and publicly available.

The third stage of the policy process is where decisions are made. This process is described as deliberation and synthesis; it is not the same as a negotiation between stakeholders. In some cases a consensus may emerge about the action to be taken. But that will often not be the outcome and here the role of deliberative synthesis is to facilitate subsequent decision by identifying areas of agreement and disagreement, and clarifying the nature and extent of differences.

The next step is deciding whether to set a standard or whether an alternative approach should be adopted; if a standard the final stage is to specify its nature and content.

This process must recognise that scientific assessments, and analyses of technology, economics and risk, must inform policy decisions, but cannot pre-empt them. Setting a standard or target is not only a scientific or technical matter, but a practical judgment which has to be made in the light of all the relevant factors.

■ Summary of an address to the Parliamentary and Scientific Committee as published in *Science in Parliament*. Reprinted by kind permission of the publishers.

Growth prospects for non-food crops

This POSTnote looks at developments in non-food crops since the 1995 POST Report, Alternatives in Agriculture. It covers crops grown for fuels, chemical feedstocks, general industrial purposes (e.g. fibre), and for cosmetics and pharmaceuticals, but excludes timber, foodstuffs for animal consumption and tobacco. It has been produced as background to the current House of Lords Science and Technology Committee enquiry into the same subject, and for more general interest.

Introduction

Before petrochemicals became widely available, agriculture played an important role in the supply of materials for industry: e.g. vegetable oils for soap; flax and cotton for weaving; and hemp for ropes. Plants also 'powered' land transport by feeding draught animals and were the main source of pharmaceuticals.

This note sets out the current status of the non-food crops industry in the UK, and considers future prospects, in their global context (such as historically low oil prices). Several key points are addressed:

- The opportunities for growing non-food crops in the current agricultural situation and the barriers to further development.
- The potential for non-food crops to replace current conventional resources (e.g. fossil fuels and chemicals derived from them).
- The environmental impact of these crops and products.
- The likely role of genetic modification.

The state of UK agriculture

Agriculture in the United Kingdom is facing a serious financial crisis. The knock-on effects of BSE, the world economic crisis, and cheap imports of both basic and processed foods, are all part of the problem. Every sector of agriculture has been affected because much produce from arable farming is used as fodder on livestock farms. The result is that many farmers are now diversifying into other areas of business, are selling land, or doing both. One area of activity with possibilities for expansion is the production of crops for non-food uses.

In 1998, approximately 150,000 hectares (kha) (roughly four times the size of the Isle of Wight) of UK land carried non-food crops (excluding timber), out of a total arable land area of over 6.3 million ha, i.e. under 3 per cent.

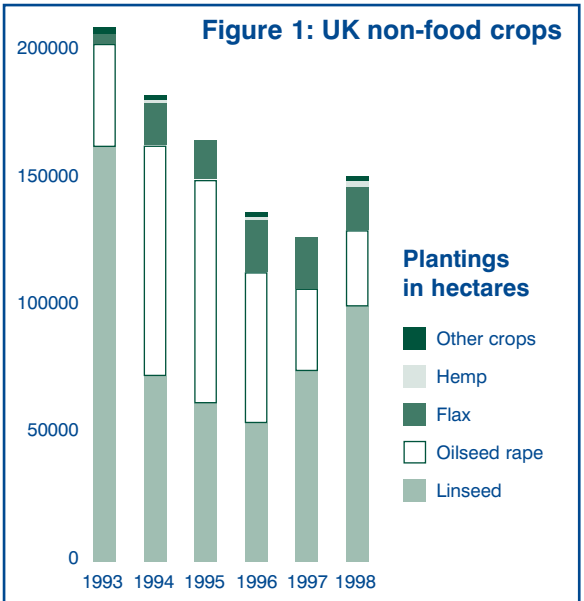
UK non-food crops

The main UK non-food crop is linseed (Figure 1), covering just over 100 kha in 1998. Although this area has almost doubled in the last three years, it is well below the 1993 level of 161 kha. The second most important crop is oilseed rape (OSR), covering 28 kha. Plantings of this crop were also considerably greater in the mid-1990s, but they have not recovered (86.8 kha were grown in 1994). Two crops that have gained in importance since the last POST report (because of higher aid levels than for linseed) are the fibre crops flax and hemp (see Table 1). Other non-food crops grown in small quantities include lavender, chamomile, evening primrose and borage.

Two important crops that are not shown above are wheat and sugar beet. These are primarily grown for food and only a small proportion is used by industry. Demand for wheat as a source of starch is, however, increasing. About 150,000 tonnes (roughly 1 per cent of total production) are now used annually by UK industry, covering about 22 kha.

The straw from various crops can also be used for industrial purposes.

Figure 1: UK non-food crops



Source: Intervention Board, Alternative Crops Unit (MAFF), Agriculture in the UK 1996, Agricultural and Horticultural Census 1998

Current uses of non-food crops

The range of possible uses for non-food crops is extensive. Many are listed in the 1995 POST Report and in a guide to *Crops for Industry and Energy in Europe* produced by the European Commission in 1997. Table 2 gives examples of some of the main products derived from non-food crops in Europe. The following sections, starting with energy crops, provide more details of non-food crop activities in the UK.

Generally, the lower volume crops attract the highest prices as they tend to be used in high value-added products such as pharmaceuticals and toiletries. Some non-food crops are used directly or with minimal processing (e.g. reeds for thatching), while others need greater processing to extract specific chemicals, oils, starches, etc. Even crops to be burnt for electricity generation usually require processing (e.g. drying and chipping or baling) to make them suitable

TABLE 1

FLAX AND HEMP PLANTINGS IN THE UK UNDER THE EU PRODUCTION SCHEME FOR FIBRE CROPS (000ha)

Year	1993	1994	1995	1996	1997	1998
Flax	2.2	17.4	16.9	20.2	19.2	16.7
Hemp	0.4	0.9	1.1	1.7	2.3	2.6

Source: MAFF Alternative Crops Unit

TABLE 2

EXAMPLES OF EUROPEAN NON-FOOD CROPS, CLASSIFIED BY END-USE

Agrochemicals	Spurge, pyrethrum, annual wormwood, caraway, quinoa
Board, composites, building and insulation materials	Hemp, flax, kenaf, cotton, common reed, miscanthus, sunflower
Cordage & sacking	Hemp, kenaf, nettle
Cosmetics and toiletries	OSR, amaranth, caraway, linseed, evening primrose, jojoba, pot marigold, coriander, bugloss
Dyes	Woad, madder, safflower
Energy and fuels	OSR, sunflower, willow, miscanthus, poplar, reeds, spurge, cordgrasses
Industrial raw materials	OSR, sunflower, castor, chicory, crambe, kenaf
Lubricants and waxes	OSR, linseed, spurge, rain daisy, honesty, meadowfoam
Paints, coatings and varnishes	Linseed, pot marigold, rain daisy, stokes aster, hemp
Paper and pulp	Hemp, flax, kenaf, miscanthus
Pharmaceutical products and nutritional supplements	Amaranth, caraway, borage, honesty, hemp, meadowfoam, linseed, evening primrose, mallows, field scabious
Plastics and polymers	Honesty, castor, meadowfoam
Resins & adhesives	Rain daisy, stokes aster
Soaps, detergents, surfactants, solvents and emulsifiers	OSR, coriander, hemp, spurge, cuphea, poppy, gold of pleasure, castor, quinoa
Textiles	Hemp, flax, nettle

Note: not all these crops are currently grown in the UK.

Source: Crops for Industry and Energy in Europe (European Commission 1997)

TABLE 3

COMPENSATION AND SUBSIDIES OF RELEVANCE TO NON-FOOD CROPS (ENGLAND, 1998)

	Rates per hectare
Set-aside and voluntary set-aside	
EU compensation under AAPS:	£306
Lower rates are paid for less productive land, for some additional voluntary set-aside land under the residual activities of a previous scheme, and for set-aside in other parts of the United Kingdom.	
Forestry Commission Woodland Grant Scheme	
Planting grants to establish short rotation coppices for biomass production (ultimately for energy generation).	
On set-aside land	£400
On non set-aside land	£600
Locational supplement for	
Project Arbre	£400/600
(depending on land used, see text)	
EU (AAPS) crop subsidies on non set-aside land	
Linseed	£467
Other oil seeds	£398
Cereals	£241
Protein crops	£349
EU subsidies for crops grown for fibre production on non set-aside land	
Hemp	£501
Flax	£536/465
(depending on method of harvesting)	

Source: Aftemative Crops Unit, MAFF

for a power station to handle.

The market for high value ingredients for health and body products is strong, although the demand on land is never likely to be particularly high, in the order of tens of hectares, rather than thousands. The fortunes of bulk crops (e.g. hemp and linseed) depend both on incentives to grow them and on demand from the marketplace. For example, hemp (*Cannabis sativa*[3]) has recently been rediscovered and marketed as one of the most versatile of non-food crops. It has now become a ubiquitous commodity available in everything from herbal remedies to paper, training shoes and varnish. Hemp also attracts a crop-specific subsidy from the EU (see Table 3). Processors aim to extract maximum value from hemp by using all its components.

Energy crops: Project Arbre and others

Project Arbre will be the first power station to be fuelled by willow short rotation coppice (SRC) (and wood chips from conventional forestry) under the Non-Fossil Fuel Obligation (NFFO)[4]. Construction is under way near Selby, Yorkshire, and the 10MWe (gross) plant is expected to be commissioned in November 1999.

SRC is a closely planted, and rapidly growing, tree crop (usually willow) which regenerates from the cut stumps and can be harvested repeatedly on a cycle as low as three years. The mean yield from SRC is currently around 7 tonnes/ha/year, with research suggesting that breeding (including using genetic modification) and better site conditions could give yields of 14-15 tonnes/ha/year. Swedish work has produced some willow types with yields of 20-22 tonnes/ha/year, although circumstances may not be directly transferable to the UK.

So far, about 200 ha of SRC have been planted for Project Arbre, but an adequate fuel reserve in the area requires about 2000 ha. The main drawbacks to achieving this are the cost of establishing SRC (about £2000/ha) and the lack of income until the crop is harvested. To compensate, an arrangement has been made, under the Woodland Grant Scheme (WGS), for a 'locational supplement' to be paid to farmers and landowners planting SRC within approximately 60 km of the Project Arbre power station. The supplement (to come from existing WGS funds) will raise the available establishment grants

to £1000/ha on all land categories. Project Arbre will pay an annual income to the farmer until harvesting and, in addition, EU compensation for set-aside land will still be available. The Ministry of Agriculture, Fisheries and Food (MAFF) are running seminars in the area to raise awareness of the opportunities.

Two larger wood-fired power stations are now in the planning stages (near Carlisle and in the Welsh Borders). Although initially intended to take waste forestry products, they could be fired by SRC, but would require plantings of 16-20 kha. Another power station is planned for Sutton, Cambridgeshire (31 MWe), fired by straw.

The DTI is currently reviewing the potential of renewable energy and a report is expected soon. Under consideration is how to achieve an initial target of 10 per cent of the national electricity supply from renewable sources by 2010. To meet this from energy crops would require some 100-150 kha to be planted. In addition to SRC, other biomass crops, mainly grasses, could be grown in the UK. These may be more attractive to farmers because they would provide annual or biennial yields.

One of the most promising alternatives or complements to SRC is *Miscanthus* (elephant grass). This perennial can be planted and harvested using standard farm machinery, requires little or no fertiliser or herbicides, has few pests, and produces 12-18 tonnes of dry matter/ha/year. Its relatively high silica and chlorine contents may cause some problems: the former produces a slag during combustion; the latter may give rise to corrosion and emissions of chlorohydrocarbons. A recent report for MAFF[5] called for a full technical and economic assessment to be conducted on the suitability of *Miscanthus* as a fuel. This should include an examination of the ash and gaseous emissions as possible sources of pollution. Other research is needed into increasing yields, the effects of fertilisers, more efficient harvesting and drying techniques and pest and disease circumstances in commercial scale plantings.

Energy crops and the environment

The Government expects energy from renewable biomass under NFFO schemes 1-5 to achieve savings in CO_2 emissions equivalent to 200-400 ktonnes of carbon. Other environmental benefits are also possible:

- SRC sites can be wildlife havens, (*Miscanthus* planted areas less so).
- Sewage sludge, landfill leachate, animal manure and slurry can be applied to land planted with SRC as a means of waste disposal, and as a source of nutrients and irrigation.
- SRC and *Miscanthus* can be grown on metal-polluted sites as part of a programme for dean-up and land stabilisation. Metals taken up by the plants can be extracted from the ash after combustion.

The principal environmental issue with biomass crops is their water demand. Various studies have shown that SRC uses more water than normal agricultural crops. The rate of water vapour release for poplar SRC may be 50-100 per cent higher than for short vegetation crops. Thus, it is likely that planting would have to be restricted to wetter, mainly western, parts of the country. The water demand may even be positive, in helping to counteract waterlogging.

Non-food crops can be the basis for low emission liquid biofuels (e.g. 'biodiesel' and bio-lubricants from OSR, and alcohols made from the fermentation of plant sugars). These products are renewable, biodegradable, have a very low sulphur content, and burn with reduced emissions compared with standard petrol and diesel. However, since the last POST report there has been little take-up in the UK, other than for niche markets where environmental sensitivity is a major concern: e.g. boat fuel on the Norfolk Broads, and lubricating oil for certain harvesting machines (where considerable loss of oil to the environment can occur). The move by traditional oil companies to produce low sulphur diesel from fossil fuels appears to have undermined one of the key potential markets for biodiesel, namely cleaner fuel for vehicle use in urban areas. Questions remain as to whether liquid biofuels can be competitive without subsidy or tax incentives.

Bulk chemicals from non-food crops

Oils: The main crop oils used by industry in the EU are extracted from OSR, sunflowers and linseed. Respectively, these are rich in oleic, linoleic and linolenic fatty acids. In addition, there are varieties of these crops that produce high concentrations of other oils: for example, oil from High Erucic Acid Oilseed Rape (HEAR) typically contains 50-60 per cent erucic add, used in the manufacture of polythene. Around 15 types of OSR, producing oils with different compositions (tailored for different markets) are now in, or close to, commercial production in the UK.

For example:

- Epoxidised oils (oils modified by adding oxygen) can be used as plasticisers and stabilisers in PVC processing, and as low viscosity binders in solvent-free paints and resins. They can replace volatile organic compounds (VOCs) which are now regulated.
- Laboratory studies suggest that adding hydroxyl units can change the viscosity of the individual fatty acids so that they might be used as friction modifiers in lubricants.
- Crop oils can also be polymerised. Again, this is useful for surface coatings, and oils with long-chain fatty acids (i.e. chains with >20 carbon atoms) can be polymerised to make bio-plastics.
- In the production of soaps and detergents, shortchain fatty acids (with 8-14 carbon atoms in a chain) are the most desirable. Typically, these are derived from imported palm kernel oil and coconut, but sunflower and OSR oil may also be used. Household detergents and personal care products based on such oild offer low toxicity, mild biodegradable surfactants with a 'green' image. This is a growth industry in the developed world. The sales of surfactants based on carbohydrates and renewable fatty acids or alcohols saw a six-fold expansion in western Europe in the five years to 1997.
- For industrial uses crop-derived surfactants may have technical advantages over conventional products for cleaning and wetting in highly alkaline systems, and for cleaning hard surfaces and textiles and in the construction industry as plasticisers. These help to modify the handling properties of cement and concrete and can reduce the amount of water that is required.[6] In principle, all classes of surfactants could be made from

renewable resources.

- The agrochemical industry uses some crop oils as the basis of biodegradable emulsifiers and solvents used in crop sprays.

Starches: The UK uses around 750,000 tonnes of plant-derived starch annually, 60% in paper and cardboard manufacturing, and the remainder in adhesives, agrochemicals, surfactants, plastics and for water purification. There are small volume, high value markets in pharmaceuticals and cosmetics, while ICI has been investigating using plant-derived starch in paint formulation.

There is a good opportunity to increase the volume of starch crops grown in the UK as 75 per cent of plant-derived starch currently comes from imported maize. In the UK, wheat and potatoes are the principal starch crops grown, but peas and oats could also be valuable and planting them would add to farm biodiversity.

Fibre crops The two main crops grown for fibre in the UK are flax and hemp, although agricultural residues (e.g. straw from cereal and oilseed crops) are also important sources. MAFF is currently funding a programme of research projects to assess whether seven other crops (including Miscanthus, nettle and marshmallow) might also be economically viable.

The main outlet for straw in the UK is as a replacement for wood in the manufacture of paper and various construction-quality boards (e.g. MDF and particle board). Straw is also used in pollution control (to mop up oil spills) and as a padding material. Its principal advantage is low material cost. For construction boards, a drawback of straw has been the presence of natural waxes that can reduce the bonding ability of the industry's preferred resins. In turn, this can limit the acceptable straw content to relatively low proportions.

There are many potential markets for plant fibres in textile manufacturing: e.g. clothing, soft furnishings, padding, lining and insulation material, and geo-textiles (used to stabilise soils). However, the UK has few processing facilities for turning flax and hemp into fibre.

Plant fibres can also substitute for glass fibres in fibre composite materials. The plant fibres (e.g. from flax) are as strong as equivalent sized glass fibres, are lighter, 25-50 per cent cheaper, easier to cut, do not cause skin irritation and can be recycled, or burnt to recover energy. The automobile industry is looking to replace fibreglass in this way, with a potential market of 80 ktonnes of fibre.

For all fibre crops, there is still considerable scope for research and development into harvesting and processing techniques, improving yields, and improving fibre consistency.[7] Better integration of the growing, processing and marketing sectors would also be of advantage. Additional positive factors of different crops may need to be emphasised. For example, the leaf canopy of hemp is so dense that spraying for weed control is not necessary. For flax, there could be advantages in farmers separating the fibres into three grades before sale: this would require good quality control and some on-farm processing, but the product would command a higher price.

Specialist crops There are over 50 specialist crops grown in small quantities in the United Kingdom: they are not discussed here in any detail. Their uses include pharmaceuticals, inks, lubricants, agrochemicals, perfumes, paints and industrial enzymes. The UK health and cosmetics market, a traditional user of herbal and vegetable extracts, was worth £850 million in 1995, with 53 per cent coming from non-food products.

Assessing environmental advantages of non-food crop products

Non-food crops are a renewable source of material and many of the products derived from them are biodegradable. The overall environmental advantages compared with using more conventional materials are not, however, self-evident.

Some industries find the renewable aspect alone to be an attractive way of meeting their own environmental aims, and there can be a marketing advantage in a finished product carrying a 'made from renewable resources' label. Proving that the product is actually better for the environment is much more difficult. This involves conducting a detailed life cycle assessment (LCA), comparing the alternative materials at each stage of their production and use, including any potential for re-use, and considering their eventual fate.

LCAs for non-food crops are complicated by having to compare the impacts from two very different systems: agricultural production and the petrochemicals industry. Some aspects are relatively straightforward, such as assessing the energy consumed to make the final product. For agriculture this would include indirect energy consumption used in producing fertilisers for the original crop. Other aspects involve subjective evaluations which are open to interpretation: for example, considering which other crops could have been grown on the land and their impacts, and whether a product is likely to be recycled, landfilled or burnt at the end of its life.

There is no co-ordinated programme for conducting non-food crop product LCAs. Only a few full LCAs have so far been carried out in the UK[8]: on OSR-derived lubricants, fuels, plastics and surfactants, though there is additional work in Europe. Some limited LCAs, which compare products only from the raw materials stage (rather than how those raw materials were produced), have been conducted and some commercial LCA databases are now available (e.g. for the paints and coatings industry). The work reported does suggest environmental advantages from the use of non-food crop derived products.

Without LCAs to provide the evidence, there is as yet no clear way of assessing if non-food crop products really are better than the alternatives on offer. Neither is there a recognised labelling system to identify the full environmental credentials of a product to potential customers.

Incentives for growing crops

Almost all of the non-food crops that are grown in the UK (apart from a small group with high commodity value) attract some form of subsidy either from the UK government or the EU (Table 3), a situation which has not changed since the earlier POST report. This makes the entire activity somewhat vulnerable to changes in fiscal and support policy.

The main source of support (for both food and non-food crops) is the EU's

Arable Area Payment Scheme (AAPS). This provides crop-specific subsidies for some crops (including linseed) and also compensation for land which the EU requires to be 'set-aside' from cereal production.

There are restrictions on how this land may be used[9], but a range of crops may be grown for non-food markets (including some which would normally be grown as food crops). For the 1998-99 crop season, a minimum of 5 per cent of any arable farmer's land must be set-aside. Further land may be set-aside voluntarily. In the UK, almost all non-food crops that do not receive a crop subsidy are planted on set-aside land.

In addition to the crop and land subsidies described above, the final products of certain crops may attract other subsidies. For example, electricity produced from the burning of SRC may also attract subsidy under the NFFO.

However, despite these subsidies, the area of land planted with non-food crops has decreased since 1994. The most significant change has been in the area of set-aside land planted. This reached a peak of 104 kha in 1994 and has fallen steadily to just under 31 kha today. The change may reflect that set-aside compensation is now around £50/ha less than it would have been if the payment had kept pace with inflation since 1994. Most commentators do not see set-aside policy, in itself, as sufficiently sound enough a basis to promote non-food crops.

Review of the Common Agricultural Policy

Consultations are currently under way on how the Common Agricultural Policy should be reformed in light of EU expansion. This will affect the AAPS system and the various incentives or subsidies given for crop production. Proposals for change were set out by the European Commission in 1997 in the document *Agenda 2000: for a stronger and wider Europe.* Some of the key proposals that will affect non-food crops are:

- All subsidies for the cereals sector should be given as non-crop-specific area payments.
- The compulsory set-aside rate should be fixed at 0 per cent. Voluntary set-aside will still be allowed and will also receive the non-crop-specific area payment.
- Crops that are not already subsidised will not be eligible for any new subsidy.

If accepted, these changes could have a major impact on non-food crop production in the EU. Planting on set-aside land may decline further, and new crops may not be introduced without subsidies that at least match those available for existing crops. Linseed is thought to be most at risk as this currently receives almost double the AAPS subsidy for cereals. In the past, linseed has been highly susceptible to subsidy rates: planting was more than halved in 1994 when the rate of subsidy was announced late. The EU already imports around two thirds of its linseed oil from the Americas.

Competition for non-food crops

There are three key factors that usually determine if a non-food crop product is used, rather than a traditional feedstock: price, quality/consistency, and security of supply. In some niche markets there may be other factors: for example, there is a small demand from the Jewish community for Kosher packaging materials which do not contain tallow.

Price is of major importance for the bulk non-food crops, as these tend to be competing with other low cost materials from well established sources (e.g. the wood pulp and mineral oil industries). As discussed, incentives for growing crops can be critical, as can be the income from secondary products, which are used to offset the price of the primary product. For example, the crushed meal that is left after extracting oil from CISR can be sold as a high protein cattle fodder. For the manufacturers there is also the cost of adapting existing machinery or processes, or both, to use non-food products. If capital investment is required or if an extra processing step has to be introduced then this could be a major disincentive.

Quality typically means having a product that is consistent, has a high proportion of the component that the user industry requires, and has a low content of undesirable materials. For example, the surface coatings industry (paints, lacquers and varnishes) may require an oil containing more than 80 per cent linoleic acid, but to be useful it must also have less than 5 per cent saturated fatty adds, whereas a higher fatty acid content may not be a problem for the surfactants industry. For the fibres industry, crop fibres will always be somewhat heterogeneous (e.g. in length, fineness, and elasticity) compared with artificial fibres.

Quality can often be improved through better separation technology (e.g. to remove poor quality material or farming rubbish from fibre crops), or through improvements in process management (e.g. to ensure that identical looking OSR seeds with different oil compositions are kept apart). In this latter case, the development of rapid testing equipment could be valuable. Quality improvements may also come from plant breeding or genetic modification. However, there are biological limits to what can be achieved while still having a plant that will grow successfully.

Security of supply is perhaps the biggest problem to overcome (e.g. when compared with petrochemicals). Farm crops are subject to flooding, drought, frosts, diseases, etc (as well as human error and wars) and it is inevitable that some crops will fail. The crops also take time to grow so demand has to be predicted at least a growing season in advance, so that it may be impossible to increase supplies if demand for a product rises suddenly. Furthermore, non-food crops need to be stored between harvest time and eventual use. This can be costly for industry, and may prove unattractive in the current ethos of 'just-in-time' manufacturing where a minimum of raw materials is held at any one time. A partial solution to this problem would be for the same crop to be grown in both the northern and southern hemispheres, so that demand can be met from at least two major harvests each year.

Other factors affecting new developments

Regulation: Under EU regulations, all 'new' chemical products[10] must now be notified to the member state 'competent authority' (in the UK, the Health and Safety Executive and the Secretary of State for the Environment). Notification involves supplying a technical document containing the results of tests to evaluate potential hazards, including possible harmful effects on humans and the environment, and an assessment of the risks (to the

environment, workers, and consumers). Once this has been accepted, the chemical can be given an 'ELINCS' (European List of Notified Chemical Substances) registration.

A chemical is considered 'new' if it is not listed in the European Inventory of Existing Commercial Chemical Substances (EINECS). The EINECS database lists over 100,000 chemicals on the market in the EU between January 1971 and September 1981. An EINECS registration does not, however, guarantee that the chemical has passed any of the same tests required for 'new' chemicals. Indeed, the European Commission has identified three priority lists of EINECS chemicals for which full-scale risk assessments need to be carried out. There are also inconsistencies in EINECS: for example, epoxidised linseed and soya oils are listed, but epoxidised OSR oil is not.

Chemicals that are not listed in either EINECS or ELINCS must undergo the notification tests before they can be marketed. The burden on industry can be considerable and may be a major factor in limiting the development of products from non-food crops. The ELINCS registration work is time consuming. Each new chemical must be assessed separately and work must begin if 10kg or more of chemical is produced. Full registration is needed for production at the tonne scale, costing £100,000-150,000 for each chemical.

The DETR has recognised the potential problems associated with EINECS/ELINCS and is currently consulting on whether it would be appropriate to seek changes to the legislation[11]. One solution might be generic registration.

The growing of new non-food crops also faces regulatory barriers: farmers are restricted in what chemicals (e.g. pesticides and herbicides) they can spray on to new crops. Each chemical has to be approved for each crop by the Pesticides Safety Directorate and, again, this is time consuming and can be costly. Manufacturers often do not carry out their own tests on what are likely to be small volume crops, in which case the farmer would have to apply for 'off-label' approval, something that its cost is likely to deter.

Genetic modification (GM): If plants are genetically modified then there are restrictions on where and when they may be planted[12]. Policy in this area may also develop in the light of recent concerns about this subject.

Genetic modification can produce higher yields of chemicals, fibres or biomass from non-food crops with improved quality. Much of the generic research being carried out on GM food crops should be directly applicable to non-food crops (e.g. GM for herbicide or drought resistance). More specific modifications (e.g. to produce unusual chemicals) may need to rely on research by the potential user industry. At present, much of this work appears to be technology-led (with seed companies engaged in speculative research), rather than being driven by industry demands. Recent concerns about the environmental effects of growing food crops could also affect policy for non-food crops.

A new method of transferring DNA using plant viruses (under development at the Scottish Crop Research Unit and elsewhere) may help overcome some of these concerns and improve the GM process. Plant viruses are relatively easy to modify to produce different chemicals, and the number of plants producing the foreign gene can be multiplied simply by injecting leaf sap from a treated plant into a new host. After a few weeks, valuable concentrations of desired chemicals could be extracted from all parts of the plant. However, the viruses do not actually transfer any genetic material to the host, nor is it usual for the viruses to be transmitted in seed or pollen, or by insects, fungi or nematode worms. It is therefore very unlikely that there would be any gene-flow into other cultivars or the wild population.

The potato virus X (PVX) is potentially one of the most useful. It can infect 240 different plant species and can be made to produce foreign chemicals as a protein 'overcoat' to the virus. After harvesting, these can be separated for use as free-standing chemicals. Because large proteins can be expressed using the virus as a vector, there is the possibility of using this method to grow vaccines and many other high value pharmaceuticals.

Research and co-ordination activities: There are now efforts to co-ordinate UK and EU non-food crop activities. The Alternative Crops Technology Interaction Network (ACTIN) was set-up in 1995 to provide a UK focus for non-food crop products and to encourage their wider use as raw materials for industry, for example, by creating cooperative initiatives between researchers and the agricultural industry. ACTIN also represents the UK on two EU bodies: the European Renewable Materials Association and IENICA (see footnote 5). The future of EU research support will depend on the final shape of the Fifth Framework Programme (to start in 1999), but over £150 million was available for non-food crops research under the Fourth Framework Programme. In the UK, MAFF annually funds around £1 million of non-food crops research through its Alternative Crops Unit; much of this has been, through LINK programmes on Crops for Industrial Uses and its current successor, Competitive Industrial Materials from Non-Food Crops. Among other major research funders are the BBSRC, the Scottish Office, and the DTI (the last for energy crops).

Conclusions

While the most immediate gain in importance of non-food crops might be as renewable energy and building resources, the longer term future could also see a highly flexible agricultural chemical production industry, where conventional crops are inoculated with GM plant viruses a few weeks before harvesting to produce whatever base chemical or drug is currently in demand.

On the other hand, decreasing incentives to grow the crops (as a result of Agenda 2000), the cost to manufacturing industry of adapting to plant-based raw materials, regulatory problems, and attitudes to GM technology, could mean that non-food crops (and products made from them) become increasingly marginal.

At present there are opportunities to grow more non-food crops in the UK, and for more of their products to replace conventional resources. For this to proceed without running into the opposition that has confronted some other recent proposals for agricultural and environmental change, the overall environmental benefits of non-food crops need to be comprehensively assessed before any major expansion programme.

Further efforts will be required to reduce costs while at the same time increasing the quality and security of supply. Some supporters of increased use of non-food crops point to recent

forecasts of future 'tightness' in world energy markets but energy prices would need to rise significantly to create market conditions for some of the energy options considered.

Also, the UK is not alone in turning its attention to the potential of non-food crops. Both Germany and the USA have recently initiated government schemes to promote research and commercialisation of non-food agricultural products, while a similar scheme begins in April 1999 in Japan. While this may be taken as a welcome sign that there is a convergence of thinking, competition between producers could become as intense as with food crops, with other countries benefiting from more favourable natural conditions than in the UK.

■ *Much of the researchfor this note was conducted by Dr T. Bradshaw, formerly Specialist Assistant to the House of Lords Select Committee on Science and Technology, during a period of secondment to POST. POST, however, retains responsibility for its contents. Parliamentary Copyright 1999. Enquiries to the Parliamentary Office of Science and Technology, House of Commons, 7 Millbank, London SW1P 3JA.*

Some useful Web sites related to the subject of this note are:

■ Alternative Crops Unit, Ministry of Agriculture, Fisheries and Food: www.maff.gov.uk/farm/acu/acu.htm

■ ACTIN: www.actin.co.uk

■ Non-food Agro-industrial Research Information Dissemination Network: www.nf-2000.org

■ IENICA; www.csl.gov.uk/ienica

References

2 Includes linseed grown on 'maincrop' land as well as on set-aside land. Some linseed oils can be used for food purposes.

3 Hemp growers in the UK require a licence from the Home Office (currently £270, rising to £300 in 1999) and may grow plants only with a low content of psychoactive chemicals.

4 The NFFO sets a contract price for electricity produced from sustainable sources for periods of up to 15 years. The difference between this price and the price of electricity from other sources is financed through a levy on electricity generated using fossil fuels.

5 Review of Research on Biomass Crops, KJ Brent for MAFF, May 1998.

6 LINK seminar on Sustainable Surfactants, 4/11/98.

7 Report on the status of non-food crops in the UK by the Alternative Crops Technology Interaction Network (ACTIN) for the Interactive European Network for Industrial Crops and their Applications (IENICA), February 1999.

8 e.g. by the energy Technology Support Unit (ETSU), Reading University, and the Scottish Agriculture College

9 e.g. herbicide use and graqzing times are restricted

10 Both natural and synthetic products

11 Sustainable production and use of chemicals, consultation paper on chemicals in the environment, DETR, 1998

12 See Genetically Modified Foods: Benefits and Risks, Regulation and Public Acceptance, POST, May 1998

Diary dates 1999-2000

21 September	GP Committee	13.00
6 October	Education Committee	10.30
6 October	Council	13.30
10 January	GP Committee	13.00
8 March	Education Committee	10.30
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