ICSTI
IRELAND

Irish Council for Science,
Technology and Innovation

ICSTI Statement

Sustainable Development in Ireland:
The Role of Science and Technology

Forfás

Established by the Government and Forfás to advise on Science, Technology and Innovation

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Sustainable Development in Ireland:

The Role of Science and Technology

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Irish Council for Science, Technology and Innovation (ICSTI)

Functions

- To advise on science, technology and innovation policy-related issues in response to specific requests from the Government (through the Minister responsible for Science and Technology) or from the Board of Forfás;

- To advise the Minister responsible for Science and Technology, the Office of Science and Technology and the Board of Forfás on the Council's own initiative, on policy for science, technology and on related matters;

- To advise the Minister on the strategy for the preparation and implementation of national programmes in science, technology and innovation;

- To advise the Minister on the strategic direction for State investment in science, technology and innovation;

- To undertake, from time to time, such other functions as the Minister may decide.

Foreword

'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'

World Commission on Environment and Development Report 'Our Common Future' (the Brundtland Report) 1987.

Sustainable development has become widely accepted as an organising principle since the publication of the Brundtland Report. This acceptance has been accompanied by many generalised declarations about the importance of science and technology to sustainable development. This Statement from ICSTI goes further. It examines how science and technology can support the achievement of sustainable development in Ireland. The Statement analyses the role of science and technology in order to identify constraints and to stimulate actions to overcome them.

The Statement is oriented primarily towards Government Departments, agencies and the science and technology community. However, one of the canons of the drive for sustainable development, and indeed of international developments on the governance of science, is the need for greater openness and transparency in the formulation of policy. This is all the more important on a subject such as sustainable development where enlisting public support will be a determinant of success. The Statement is, therefore, being published to inform public discussion on a subject of great importance to the future of everyone on this island.

The economic prosperity and quality of life of the present and future generations will depend crucially on equipping our scientists and technologists with the structures and funding to enable them to contribute effectively. Their contribution is essential if we are to overcome the barriers to sustainable development. The Statement examines the nature of these barriers and makes recommendations to Government about the steps needed to bring about improved capability for tackling them within the context of our own economy.

But sustainable development in Ireland is not only about tackling the problems that are of our own making. The Statement also emphasises that Ireland needs to play its proper part in what is a global science and technology endeavour and that we should look beyond our own shores at what we ought to be doing. The 2002 World Summit on Sustainable Development in Johannesburg agreed a commitment by the developed countries to contribute to international initiatives to improve the science and technology capacity of the developing countries so that they are better able to solve problems at source. In a globalised world, other people's problems will inevitably affect us sooner, or later.

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Executive Summary

This Statement from the Irish Council for Science, Technology and Innovation (ICSTI) considers the implications for Irish public policy of sustainable development as a national and international goal. In the light of the increasing interest in, and commitment to, sustainable development as an overarching concept in economic, environmental and social policies, ICSTI identified constraints and opportunities and made recommendations to enable science and technology to make a fuller contribution to sustainable growth.

The Council reviewed the need for change in the light of international political developments and the widespread view that a 'business as usual' approach will lead to significant environmental problems, economic crises and social tensions. There is a degree of urgency to tackle the problems. Some of them are affecting us now and others are accumulating for the future. The Council fully concurred with that view and this Statement specifically addresses the challenges for Ireland which it poses. Although the challenges tend naturally to be dominated by the potential constraints on economic development, there are also substantial opportunities in global markets for innovative technological solutions to environmental and social problems.

In particular, the Council examined the part science and technology should play, in the Irish context, in supporting sustainable development. International policy developments on the role of science and technology have also been reviewed in a separate study. A broad definition of science and technology has been adopted, embracing the economic and social sciences as well as the natural and physical sciences. A particular underlying issue was seen as the need to move from the tight disciplinary approach of our science and technology structures to greater integration and strengthening of linkages both within science and technology and holistically with policy development in Government.

In defining the contribution of science and technology, the Council did not attempt a wall-to-wall analysis across the whole spectrum of

economic and social activity. Rather, the approach adopted was to examine three case studies from which to obtain general insight into the diverse constraints and opportunities that apply to them. The case studies covered the areas of renewable energy, agriculture and forestry, and clean technologies, giving insight into both a particular industry and into cross-industry processes. The Council met small groups of people, knowledgeable in the three areas, and representative of the relevant science and technology expertises, as well as practitioners from the industries involved.

It was clear from this limited, though individually highly important selection of activities, that there are strong commonalities in the measures needed to overcome the constraints and seize the opportunities. Issues affecting the environment are currently the dominant focus of worldwide attention in sustainable development and this emphasis is inevitably reflected in the Council's analysis. Nonetheless, the Council was able to identify social and economic factors pervading the three areas examined. The examination of the case studies allowed the identification of necessary actions and the making of recommendations on R&D needs together with the operational implementation of improvements. A draft of the Council's report was circulated widely in Government and comments received have been incorporated.

The conclusions of the Council's analysis and of the review of international policy developments together pointed to the desirability of a framework of principles to bring policy coherence to the many dimensions of the role of science and technology. The framework addresses particular themes which affect the capability of science and technology in supporting the high level activities of framing and implementing integrated policy options. In the wider context, the role of science and technology should also encompass the need to enable Ireland to play its proper part in the global endeavour and the framework includes that as a strategic aim.

1.0 Background: Sustainability on the Agenda

Over the last three decades, numerous studies, reports and memoranda have made dire predictions about what is likely to happen if governments, businesses and consumers do not change their patterns of behaviour. These studies and reports have made it clear that a 'business as usual' approach will lead to significant environmental problems, economic crises and social tensions.

This outlook has made sustainability a popular term in political debate. In essence, it means "sustaining the ability of a system to function in the long term. Underlying this term is the need for societies to check whether patterns of behaviour and political, technological and economic decisions do not damage the prospects for future generations to enjoy a full economic and social life, without serious impairment to environmental endowments and life support systems.

Under the increasingly inclusive concept of sustainability, governments and inter-governmental organisations are asking: will we, and particularly our children and grandchildren, still have the choices and opportunities that we currently have? Will our lifestyle lead to such an accumulation of problems that we, and future generations, will be subject to many constraints and a clear reduction in quality of life?

Sustainable development requires us to lead our lives in such a way that future opportunities for economic and social development will not be so diminished or inequitably distributed as to lead to political upheaval. It is a vision of what it takes to avoid crises and to eliminate threats to the stability of our existence. It shows us the many and varied considerations that have to be taken into account and emphasises the need for a balanced decision on the direction to take without being able to tell us, in detail, what the objective of a sustainable future looks like or to prescribe how best we can reach it.

The more seriously we examine the 'route map', the more closely the discussion on sustainable development comes to resemble a debate on the right concept for structuring national and even global society. The

notion of sustainable development relies on a transparent process of debate and learning involving the whole of society, in a way, largely unknown until now. As a result, sustainable development is one of the most demanding, but also one of the most complex, concepts which political thinking can give rise to.

Sustainable development as a new paradigm poses the challenge of thinking in the medium to long term, instead of the short term. It challenges societies to work in an interactive and cooperative way, instead of in categories defined by self-interest. It challenges them to reconcile conflicting rationalities in work practices in science and politics and to link efficiency, fairness and provision.

Sustainable development, as a concept, allows us to appreciate better how we can optimise the process of shaping the future and that politics, aided by science and technology (S&T), can take a more active role in that process. S&T analysis and research can make the possible consequences of decisions or lack of action clear. The "learn and search" process for the most suitable pathways to sustainability can be organised more efficiently by means of such signposting. This places S&T firmly on the sustainable development agenda.

2.0 The Context for the Role of Science and Technology (S&T)

The truth of Muir's famous dictum, 'Everything is connected to everything else in the universe', is becoming ever more obvious as economies merge into global interdependencies, and for the first time in human history, our technologies and the ways people use them have the capacity to transform the biosphere itself.

At the Global Sustainability Summits in Rio de Janeiro in 1992 and Johannesburg in 2002, countries committed to developing along a sustainable path, and over the past decade, numerous international agreements, for example, on climate change, biodiversity and social development, have been entered into. Under the Kyoto Protocol and the Biodiversity Convention, for example, governments have looked beyond short-term interests and have made commitments that are intended to protect and improve the environment in the long term. In these and in many other similar cases, scientific analysis, informed by research, has been centrally involved, both in defining the problems and in developing strategies which shape policy. Such commitments have become part of the European Union's (EU) template for environmental policy and are translated into EU and, then, Irish law via Directives, Regulations and the like.

Representative bodies of the international scientific community, such as the International Council of Scientific Unions (ICSU) and the World Congress on Science, have underlined, in significant policy statements, the contribution of S&T to sustainable development. The ICSU, representing hundreds of national academies and professional bodies, observed, in preparations for the 2002 World Summit on Sustainable Development in Johannesburg:

"Sustainability has become a 'high table' issue in international affairs, and on many regional, national, and local agendas. Though visions of sustainability vary across regions and circumstances, a broad international agreement has emerged that its goals should be to foster a transition toward development paths that meet human needs while preserving the earth's life support systems and alleviating hunger and poverty i.e. that integrate the three pillars of

environmental, social and economic sustainability. Science and technology are increasingly recognized to be central to both the origins of sustainability challenges, and to the prospects for successfully dealing with them. Decision makers, at all levels, need timely, reliable access to the knowledge generated by science and engineering to introduce rational policies that reflect a better understanding of complex technical, economic, social, cultural and ethical issues concerning the society, the earth, and its environment".

The ICSU, along with government and inter-governmental agencies, subscribed to the statement of the 1999 World Congress on Science and the Use of Scientific Knowledge, which urged a more central role for science in policy formation:

"Enhancing the role of science for a more equitable, prosperous and sustainable world requires the long-term commitment of all stakeholders, public and private, through greater investment, the appropriate review of investment priorities, and the sharing of scientific knowledge. Science decision-making and priority-setting should be made an integral part of overall development planning and the formulation of sustainable development strategies".

UN Secretary, General Kofi Annan, previewing the World Summit on Sustainable Development in Johannesburg in 2002, noted that "the model of development that has brought us so much has also exacted a heavy toll on the planet and its resources. It may not be sustainable even for those who have already benefited, let alone for the vast majority of our fellow human beings, many of whom live in conditions of absolute deprivation 'So far, our scientific understanding continues to run ahead of our social and political response'.

The international scientific community, in its contributions to preparations for the Johannesburg Summit, recognised the need for science to make itself more policy-relevant. A 'dialogue paper', prepared by a consortium of international scientific bodies, urged problem-oriented and interdisciplinary research that addresses the social, economic and environmental pillars of sustainable

development.The scientific organisations stressed the need to overcome divisions between the natural and social sciences, and proposed that research agendas must be defined through broad-based, participatory approaches involving those in need of scientific information.

The European Union (EU) has also committed itself to ensuring that S&T plays its part in sustainable development. The Union's Research Directorate General stated that science has now been 'requisitioned' to formulate possible adaptations and remedies as a basis for sustainable development. It added that "there is now a general awareness of the need to better integrate research on economic and social sciences".

This global and European context has engendered a policy response from various Government Departments and agencies in Ireland, exemplified by the Sustainable Development Strategy 2002-2005 of the Department of Enterprise, Trade and Employment, which inter alia commits to:

- production of a practical guide to sustainability proofing;
- development and implementation of an accompanying training programme;
- integration of sustainable development at a core level in all future Department statements of strategy;
- deepening of internal knowledge of the linkages between economic, social and environmental dimensions of the Department's work.

The report from the Department of Environment to the Johannesburg Summit, Making Ireland's Development Sustainable (2002), emphasised that 'economy and environment are complementary'. The report reviewed policy initiatives over the previous decade and noted that 'policy development will be supported by research to determine the state of the environment, identify emerging trends and help devise policy and technological solutions'.

Comhar, the National Sustainable Development Partnership, which represents the interests of Government, business and non-Governmental organisations in issues of sustainable development, published, in 2002, a framework of Principles for Sustainable Development. These principles, encompassing environmental, social, global and political dimensions of sustainable development, are discussed in terms of significance, meaning and justification. The relevance of each principle in the Irish context is further elaborated. The principles are intended to provide a benchmark for both existing and future policies, to determine whether policies are likely to contribute to, or impede sustainable development. Comhar acknowledged that major challenges lie ahead in developing and implementing policies in all areas. Action plans and targets arising from the adoption of the principles are not addressed in the framework.

A significant feature of the tone of the international debate is the emphasis - perhaps over emphasis - on sustainable development as being about the 'future' and the 'long term'. Yet the problems are patently with us now - in the form of environmental degradation, social exclusion, overuse of non-renewable natural resources, and so on. The emphasis on the future and the urgings for S&T input could induce complacency in Ireland and a belief that solutions and technical fixes will be emerge in due course. However, many of the effects deriving from our way of life are irreversible and their continued accumulation will impose a legacy of problems for future generations. No research will be able to reverse them, though research will be needed to quantify them and to explore alternative practices that avoid them or mitigate their impacts. Time is not on our side and S&T inevitably has an important immediate contribution to make in defining the nature and extent of problems and devising solutions based on the best available existing knowledge.

The above acknowledges the urgency of the issue though they are generally phrased in terms of aspirational objectives and exhortations. They have little to say on how the contribution of S&T

can best be organised to fulfil the identified need. This is not an insignificant problem in itself since S&T advance has a strong disciplinary focus whereas sustainable development objectives impose a need for integration across discipline boundaries, just as it does at the higher level of policy integration. It is important to avoid recourse to reductionism whereby issues are conveniently segregated into individual policy and associated scientific areas with the danger of not identifying overall system properties ('emergent properties') that are not possessed by any of the individual components considered in isolation. The present Statement is prompted by awareness that the connections between S&T and policy, and between environment and economy, have not yet been effectively forged in Ireland. These connections have been the subject of examination and action elsewhere from which useful lessons for Ireland can be drawn. A review of international developments on S&T policies pertaining to delivery of sustainable development objectives has been carried out in conjunction with the preparation of this Statement. Some relevant conclusions of that review are discussed below.

3.0 The Challenges for Ireland

As the fastest growing economy in the EU for the past decade, Ireland faces a singular challenge in fulfilling the commitments contained in international conventions and agreements. In relation to climate change and the emission of 'acid rain', and in relation to the per capita volume of dangerous and municipal waste going to final disposal, Ireland is struggling at the back of the European class to make progress. For example, a recent EU survey showed that Ireland is third from the bottom in the list of Member States in terms of meeting its share of the Union's collective goal of reducing greenhouse gas emissions by 8% before 2010.

There is a strong emphasis throughout this Statement on the environmental dimension of sustainable development. The justification for this is the sheer scale of the economic value to Ireland of goods and services available from the environment compared, for example, to countries dependant on the consumption of non-renewable materials to sustain industrial activity. This value is in the form of renewable natural resources, such as harvestable crops, animals and fish, of the natural processes that help to sustain life, such as potable water filtered through permeable strata, and the aesthetic value of the natural world. It is incontrovertible that the percentage of Ireland's GDP that depends, in one way or another, on a healthy environment, must be very high indeed and this supports the emphasis in the Statement. It is fundamental to sustainable development that economic prosperity must not be at the expense of environmental degradation. This is true for the world in general, but true in particular as regards this island. The environment of Ireland is not a free resource to be squandered. For the food industry, for example, a high quality environment confers a considerable competitive advantage that must be preserved. Surveys of visitors to Ireland, again and again, report that it is people, culture and the natural heritage that brings visitors here, and brings them back. If a perception develops that any one of these three has weakened, it would have negative consequences for Ireland's tourist industry. New knowledge based service industries depend also on a good environment as part of the quality of life.

For companies, the advantages of a high quality of environmental stewardship are also clear. A combination of better positioning with environmentally aware consumers, and better chances of securing planning and licensing permissions, all make the case for high quality stewardship. The US healthcare products corporation, Johnson and Johnson, states in its 'credo': "We must maintain in good order the property we are privileged to use, protecting the environment and natural resources." Shell, the energy multinational, has a five-year agreement with the Smithsonian Institution under which the Institution is assessing the impact of Shell's operations in areas of high biodiversity value. A first joint project, in Gabon, Africa, involves local scientists identifying the total number of species in an area where Shell is active. Shell has stated: "There is a clear business case for sustainable development. Long-term competitive success depends on being trusted to meet society's expectations".

An important aspect of the challenge for Ireland is the immediacy of the problems: how vulnerable is economic development in Ireland to the irreversible effects? How does Ireland compare in international league tables? How rapidly is Ireland moving towards finding and implementing solutions or mitigation measures? Furthermore, such figures, as are available, mainly relate to current conditions whereas rates of change and future projections reflecting economic and population growth are, if anything, more important. Examples of questions for which the answers would be indicative of the scale, nature and timing of the issue of sustainable development are:

- How far away is the future that is being talked about and will it come sooner in Ireland than in other countries given projected rates of change? Is Ireland facing a more immediate problem than other countries?

- What scenarios are envisaged about the state of the country if 'business as usual' continues for 5, 10, 20 years? Will it be better or worse in terms of environmental degradation, life style and economic prosperity than relevant international comparators?

- What is the ecological footprint of Ireland now? How much of the world's scarce resources are being consumed per capita in Ireland compared to an equitable distribution across the world? Is it improving or getting worse?

This kind of strategic information, or judgments if hard information is not available, can only come from embedding sustainable development as a concept in the practice of Government and from utilisation of comprehensive S&T analysis.

An example of such a programme of information gathering and analysis is contained in the statement on a National Environmental Monitoring Programme for Transitional, Coastal and Marine Waters published, in October 2003, by the Environmental Protection Agency (EPA). It illustrates very well the scale of effort needed in one area of environmental protection to obtain a comprehensive information source on which to base policies and priorities for action. The statement assesses the extent of monitoring activities deemed to be necessary for the protection of the Irish maritime environment under national and European legislation and under international conventions. The proposed Programme builds on existing monitoring activities and includes proposals for new and revised monitoring based on a review of these obligations. In addition, the monitoring programmes, covering 36 separate subjects, are designed to address particular pressures affecting individual sites, their impacts on environmental quality and the anticipated risks of their failing to meet environmental objectives. Important benefits of the Programme include more efficient identification of gaps in monitoring arrangements and of the need for programmes of measures to address environmental problems, as well as more readily accessible and consistent information to provide an improved basis for environmental management and policy formulation.

In relation to current practices, there is a variety of policy instruments available, or being planned, to harmonise economic, environmental and social development in Ireland, as in all other advanced countries These include:

- regulation, such as Integrated Pollution Prevention and Control (IPPC) licences, as managed by the EPA;
- voluntary agreements, like the collective agreement on packaging waste administered by REPAK;
- negotiated agreements with energy users on emission reduction under the National Climate Change Strategy;
- levies and taxes to influence behaviour in an environmentally responsible direction, such as the levy on plastic bags (Ireland uses only a small number of such financial instruments; a levy on plastic bags does not match what taxes on resource usage might achieve);
- emissions trading, which allows eligible emitters to meet their emission targets by buying or selling permits from other emitters;
- providing information, such as the information to farmers about when and under what conditions application of nitrogen and phosphate might be environmentally damaging or a waste of money;
- direct investment in environmental infrastructure, as in the case of the EU-supported investment in wastewater treatment.

Some of these instruments depend fundamentally on the options available to eliminate or reduce environmental pollution, that is, they depend on the effective application of existing technologies or the development of new, cleaner technologies which contribute to a more sustainable development and a better quality of life. Others depend on the development of a better understanding of how businesses and people modify their behaviour in response to incentives. There is also scope for new policy instruments to provide incentives to promote more sustainable consumption of resources, such as water, land and minerals.

A particular challenge is how the S&T system can be more active and effective in assisting the political system in making socially acceptable decisions in the national context and in formulating and facilitating the achievement of international objectives for which S&T has a contribution to make. It should not be looked upon only as providers of (apparently objective) facts and analysis, still less as promoters of the need for further research. In the framing and implementation of policies on the uncertain issues of sustainable development, S&T can create choices where none existed before, give new insights, new information that will allow priorities to be set, new, lower-cost and better solutions to be identified, and environmental endowments to be conserved while progressing economically and socially. In this way, and in many other ways, sustainable development encompasses economic, social and environmental aspects. It is important to understand the ecological basis of sustainable development in order to plan for a more sustainable future. It is also important to understand the social basis and, in particular, the factors influencing trust and confidence in science and in the institutions of the State. People must have "know why" to allow them to develop or understand "know-how" or at least to encourage them to conform to non-regulated societal expectations..

In this context, the domain of science needs also to encompass social science. Conventional S&T form only part of the picture. Mechanisms need to be found to encourage the development of "soft" solutions, that is, solutions that are not technology-based or depend on enforcement of financial penalties. Deeper understanding of social perceptions, attitudes and influences on individual and group behaviour can help develop such mechanisms.

S&T has an important contribution to make to the decoupling of negative environmental impacts from economic development. This decoupling would set into reverse the longstanding reliance of the industrial economies on achieving growth through living off the world's environmental capital. However, some stakeholders would undoubtedly see the connections differently: they will see

commitments to improved environmental management as difficult to square with the drive to increase individual and collective prosperity. Such beliefs run counter to the imperative of sustainable development and present a challenge that cannot be avoided, though the context will be all-important. There are circumstances in which efforts to ensure, as best we can, that future generations enjoy a high quality of environmental, economic and social life, can also deliver economic and social benefits for the present generation. There are, in other words, 'win-win-win' options, for example investment in efficient public transport systems.

In other cases, however, we face trade-offs. The benefits and risks at the commercial and economic levels have to be balanced against the costs and risks at the environmental and social levels.So it may be that undertaking a particular process in an environmentally benign fashion can typically only be achieved at a net financial cost - it is not 'win-win' with current knowledge and technology, though the balance depends crucially on whether the benefits of the environmentally benign option can be internalised, by suitable economic instruments, to offset the costs incurred in achieving it. The balance must also be harmonious and, in the words of the Comhar framework of principles, it must not undermine the system as a whole, even if progress is made in one particular area.

In Ireland, current policy priorities are focused primarily on job creation. The worldwide drive for sustainable development will bring opportunities for participating in the development of innovative technological solutions. There is consequently an economic 'upside' to the need to embrace sustainable development as a national priority accompanying any perceptions of the 'downsides'. It is in Ireland's interests that the challenge of participating in markets for new products and processes should also be addressed as part of the policy response to sustainable development. This aspect will be discussed further below.

Such examples exemplify precisely the connections between S&T and the challenges of sustainable development. The point of S&T in this context is to provide analytical frameworks, for the exercise of choice and by R&D, to create new and better choices, to move, if possible, from trade-offs to 'win-win-win'.

However, it is important to appreciate that sustainable development is not confined to reducing the costs of responsible environmental stewardship, whether by hardware or software solutions. Implementation of sustainable development requires a consensus-based decision making process involving all the parties concerned. There is thus a need for developing new ways of achieving consensus over and above simply understanding better what motivates the behaviour of the public and acting accordingly in the hope that trust will ensure compliance. This process of democratising decision-making imposes new demands on the S&T community to be more transparent, ready to offer explanation without suppressing the uncertainties, prepared to engage in the debates and helping to structure the debates to ensure a satisfactory outcome. The challenge of sustainable development extends also, by definition, to such matters as the alleviation of poverty, reduction of crime, substitution of wasteful consumption and protection of the vulnerable from distributional injustices associated with policies that are beneficial in the mean. Furthermore, the focus of attention cannot be confined to the state of one's own national backyard. Returning to Muir's dictum quoted earlier, it follows that it cannot be sustainable for Ireland to export its problems or not to play its part in seeking solutions to problems elsewhere that, in one way or another, impact on Ireland now or will do so in the future. In some of the above areas, there will be a clear role for S&T in generating information and advice and contributing to policy-making whilst in others, for example overseas assistance, the role can develop to support wider government policy initiatives or can be encouraged by voluntary actions, by particular professions or by business. In this context, a relevant initiative with potential implications for S&T input is the recent establishment of the Private Sector Forum for Development, a Government-backed body to promote links between Irish business and the developing world.

4.0 The Scope for Innovation

A principal source of dissension in the drive to secure sustainable development is the fear that potentially negative effects on economic growth and freedom of choice will result from the need to comply with burdensome and restrictive requirements. This is rather too limited a perspective though one from which this Statement is, itself, not immune. It is inevitable that the concentration is on the challenges to sustainable development in Ireland posed by current practices - it is easier to identify and deplore what is not sustainable than it is to identify practicable and cost-effective alternatives that would be socially acceptable. To some extent this is a question of timing - there is a job of persuasion to be done ahead of developing and getting acceptance of solutions that will involve sacrifices. Despite this, a balanced argument has to include consideration of the undoubted opportunities for innovation and exploitation of new ideas that will be opened up once the persuasion has been achieved. It was estimated, in 1994, that the world market for environmental technologies would amount to over $500 billion by the year 2010 and there is little doubt that this estimate could now be revised substantially upwards. It is in Ireland's interests that it should be among the innovators and early adopters rather than the laggards of the innovation cycle.

There is a challenge in identifying and encouraging areas where Ireland could take an international lead in niches that fit with the Irish economy and its characteristics (for example, the entrepreneurial spirit) but also have potential earning capacity in international markets as other countries seek solutions to their own problems. A good example of an exercise with those objectives is the analysis of options for the development of wave energy in Ireland, published for consultation in November 2002, by the Marine Institute and Sustainable Energy Ireland. The document focused on the current status and longer-term development potential of wave energy technology, recognising that the wave climate off the West coast of Ireland is one of the most favourable in the world. The creation of an industry to construct converters for use in Ireland as well as providing

technology and converters for export was regarded as a viable objective though requiring significant investment. The document also assessed the effectiveness of existing R&D programmes and the capabilities of existing centres of expertise in Ireland. A set of strategic options was proposed with different levels of investment and risks, with the ultimate aim of informing the development of a National Strategy for Ocean Energy of which wave energy might be an important component. The model of Denmark was regarded as highly relevant in the analysis, with the emphasis and encouragement that had been given to the provision of local renewable energy sources and to the development of associated technologies following the 1970s oil crisis. Other possible niche areas pertaining to Ireland include organic agriculture, water treatment, industrial ecology, micro generation of power and alleviation of the environmental problems of fish farming. The evaluation of areas for innovation in Ireland and their encouragement by government action in R&D programmes has to be an integral part of a balanced response to the challenges of sustainable development.

5.0 International Developments

The above discussion has shown that the role of S&T has been the subject of much coverage of a general kind in international pronouncements on strategies and policies relating to sustainable development. These have recognised the importance of S&T and have established S&T firmly on the agenda, but there remains the task of defining the most effective ways that the role can be fulfilled. Pertinent issues that arise include the urgency of using existing S&T knowledge and applying S&T judgments to give direction now, as distinct from the longer term endeavour of identifying areas for further research. The latter raises questions of the structures needed for pursuing research on a cross-cutting topic such as sustainable development. In both of these areas, significant international deliberation has taken place and merit attention in order to set a framework for action in the Irish context.

Of most immediate relevance is the 2002 World Summit on Sustainable Development (WSSD) referred to earlier. The focus of attention of WSSD was on identifying and seeking agreement on measures to alleviate problems of the South - mainly poverty, water, education, S&T capability - by actions by the North. The Summit's conclusions included relevant general points about scientific understanding and research agendas. An issue in the present context is how S&T activities in Ireland on sustainable development should be developed to give specific support to the government's commitments to the WSSD outcomes.

In preparation for WSSD, the leading National Academies of Science of the world published a statement in 2000. The statement, entitled 'Transition to Sustainability in the 21st Century: The Contribution of Science and Technology', identified priority avenues for S&T policy actions by the developed economies. This authoritative framework of priorities provides pointers to how S&T in Ireland could play its part in the international endeavour. An important general point about the role of S&T is contained in the Academies' statement that 'The values of the scientific enterprise - openness, community, quality and respect for evidence - are of great importance to the search for

sustainability.' The message from this is that it is not sufficient to look upon the S&T community as simply a provider of information, on tap when the need arises, but S&T should also be brought into play in framing the issues and contributing to strategic developments.

The EC's Sustainable Development Strategy, agreed at the Gothenburg Council in 2001, represents an important framework for action. The strategy set out six main threats to sustainable development in Europe. A pertinent policy question is whether the Europe-wide assignment of the main threats is applicable to Irish conditions or whether there are other threats specific to Ireland that warrant a higher priority. The EC strategy also identified the requirements to tackle the threats. In general, most of the requirements are referred to in one way or another in the discussions elsewhere in this statement. However, one of the EC's requirements - of responsible partnership in a globalised world - merits further attention. The main emphasis in the debate on sustainable development in Ireland is on the international policies that have technical repercussions on Ireland, particularly in relation to pollution and greenhouse gas emissions. It is also important to consider the desirability and benefits of Ireland devoting at least part of its S&T investment to furthering WSSD's and EC's policies, by capitalising on Ireland's advantages, for example a young and highly S&T-literate population and an accepted tradition of assisting developing countries. In addition to this, there is Ireland's self-interest in having an outward looking policy of actively seeking to influence progress beyond its borders since many of the adverse effects of non-sustainable activities elsewhere will be reflected back to Ireland in the longer term.

In the UK, an important element of policy development has been the action taken by government to establish and fund institutions for generating and encouraging deliberation on sustainable development choices and preparing advice to government. Superimposed on this is a policy of active collaboration with non-governmental organisations and professional bodies. The Sustainable Development Commission acts as an independent advisor to government, with a mission to

inspire government, the economy and society to embrace sustainable development as a central organising principle. Comhar, established in 1999, fulfils a similar role in Ireland. An example more pertinent to S&T is the Sustainable Development Research Network funded by the UK government to facilitate the better use of evidence and research in policy making. These developments and others in the UK - probably mirrored in other countries - are an explicit recognition that sustainable development cuts across existing arrangements. Although a necessary first step is to pursue policies within existing institutional arrangements, the reality is that there are powerful barriers to the necessary integration and joined-up thinking. New and more broadly-based structures are needed to overcome the barriers and to help ensure consistency of purpose across the spectrum of policies. The establishment of Sustainable Energy Ireland is a step in the right direction, though its remit is confined to a specific issue. A major (and admittedly complex) question is that of the interdependency of policies, giving rise to effects ('emergent properties') that are not brought to light by analysis of individual policies in isolation from each other. This question is currently occupying the attention of the EC, for example in relation to the Commission's policies on environment and public health. This question of systems integration is one on which the considerable expertise developed for engineering systems can play an important role.

A pervasive international policy issue is that of assessing the degree to which current performance and expected progress are consistent with sustainable development. The political system and society in general have an immediate need for this information so that the efforts and sacrifices required for sustainable development can be properly informed on the basis of actual evidence and justifiable conjecture. There is a lack of international consensus on many important matters relating to sustainable development, as exemplified by the 'contraction and convergence' idea currently being pursued as an alternative to the Kyoto protocol. More generally, there is much activity on and promotion of frameworks for assessment. The

frameworks may not give a unanimous view on whether a particular action contributes to sustainable development and whether the contribution is worthwhile in relation to the sacrifices which would be involved. The view will depend on where the system boundary is drawn and will require judgments to be made as much as reliance on established facts. This inevitably leads to dissension and political difficulty. The development of expertise in assessment deserves as much attention as the collection of scientific data on effects and information on social behaviours. The issue has additional policy relevance since the EC is moving towards the structuring of directives - for example, on Integrated Product Policy (IPP) - that rely on information about use and disposal and, hence, inform the effectiveness of intervention policies at different stages of the life cycle. A topical illustration of the effectiveness of intervening at the right stage of the life cycle is provided by the evidence that the effectiveness of control on the use of plastic bags greatly exceeds the effectiveness of measures to control their disposal. A further dimension is that the IPP proposal departs from the usual form of directive in that it will not set down a precise threshold to be attained, after which producers can relax. Rather, the aim will be to foster continuous improvement in the light of information on impact and on technological opportunities for reduction of that impact, both areas in which S&T information will dominate. It is recognised that this should stimulate front runners to develop greener products and provide a spur to innovation. There is also in prospect a framework directive on the integration of environmental considerations systematically into the product design and production process. For all these reasons, the development of capability in assessment, using existing S&T knowledge, as well as research to enhance that knowledge, are widely seen in Europe as essential complements to policy-making on sustainable development.

The issue of lack of agreement on assessment is probably the major constraint on progress, offering scope for making excuses for inaction. Several international developments attempt to address the issue. First, the argument is made that it is easier, in the first place, to get agreement on what is wrong - adverse effects on sustainable development are usually obvious - than to try to agree on what is thought to be the right thing to do. This is the logic behind the attention given to sustainable development indicators. Much effort has been given in the UK to developing a structured suite of indicators as part of the government's sustainable development strategy. They are variously quantitative or qualitative. Annual reports of trends are now a feature of the sustainable development landscape. They help to evaluate the impact of and give new direction and emphasis to policies. In particular, they serve to identify areas where S&T would have potentially the biggest impact and where information from research would have the greatest value. The generation of national information bases, interpreted as being in the form of a set of traceable and relevant indicators, would bring Irish practice into line with other countries and allow comparisons of progress to be made.

The second point to be made on the difficulties of assessment is that indicators, on their own, are not sufficient for making decisions. They give no information on the cost-benefit balance, on the consequences of inaction or inadequate action (other than in well-researched areas such as climate change) and on what may actually be achievable in the current state of S&T and public attitudes. There are rarely any objectively 'right' answers to the real life problems of sustainable development since the topic is pervaded by uncertainties. This raises basic questions about how the uncertainties are defined and handled and the level of risk, for example, in energy supply where the concept of 'security of supply' can only be given meaning in terms of risk. The role of S&T in providing the best available advice, based on current knowledge and expert judgment, requires that the nature of the uncertainties in the advice should be described and explained. The

uncertainties will influence the structuring of policies on how the risks are managed and how the public are involved in making decisions. The nature of the uncertainties affects the balance between acting on S&T advice and respect for public values as legitimate drivers of decisions. At one extreme, application of authoritative good practice in handling uncertainties based on established S&T knowledge will dominate the routine decisions. Where the basis of S&T knowledge is inadequate, political application of the Precautionary Principle may be necessary at the other. This question of legitimacy of roles in decision-making is a fertile area of international discussion and research. The way in which S&T interacts with policy making and the extent to which the process is open and transparent are recognised internationally as crucial to public acquiescence in unpopular decisions. The need for greater transparency is a facet of sustainable development decision-making that impacts directly on the role of S&T.

Decisions on sustainable development may not allow the luxury of waiting until relevant baseline information is known and an adequate understanding has been gained of underlying processes and causes. The problems raised for the decision-maker are two-fold:

- what is 'relevant' information and
- what constitutes the 'right' decision in the light of the available understanding?

These policy problems have to be tackled as a prior matter if 'paralysis by analysis' is to be avoided. This has been recognised internationally in the efforts to develop sustainable development indicators, though it has not always been done in a systematic manner. But there is general recognition that there should first be an understanding and consensus on the current state and the means for describing that state. A recent report from the US well illustrates a rigorous approach to gaining that understanding, involving a variety of actors in addition to the S&T community. The report, entitled 'The State of the Nation's Ecosystems: Measuring the Lands, Waters and Living

Resources of the United States', was produced by the H. John Heinz III Center for Science, Economics and Environment in late 2002. The target audiences included decision-makers, opinion leaders and the public. Several aspects of the approach are worth listing. The process by which the report was produced was intended to achieve the three complementary goals of policy relevance, technical credibility and political legitimacy so that the information would be useful in a broad policy arena and not, itself, the subject of debate. The report was to be strategic, not encyclopaedic, in order to communicate vital information concisely to busy decision-makers and opinion leaders. It was to include information on both the condition of the ecosystems and the goods and services that people derive from them. Finally, it was envisioned as a vehicle to bring information across a key boundary - between science and policy-making - with no attempt to resolve contentious policy issues or unresolved scientific issues of cause and effect. A key lesson from the preparation of the report is stated to be that careful attention to the relevance, credibility and legitimacy of both inputs to the environmental policy debate and the processes by which the inputs are developed is crucial to their ultimate success. This lesson needs to be adopted as an overarching principle in establishing baseline information on the way that sustainable development is described in the Irish context.

Aside from the framework for the role of S&T, there has also been much deliberation on how the role of research, as a subset of the role of S&T, is best fulfilled. This is not a trivial question, as exemplified by the efforts being devoted at European and national levels to the question. The Institute for Prospective Technological Studies of the EC's Joint Research Centre has concluded from an extensive analysis of the research programmes of different countries that the design of research programmes, addressing different aspects of sustainable development, is an extremely challenging task. The analysis addressed pertinent questions:

- what can be considered best practice in the organisation of programmes targeted towards sustainable development at the national level?
- what can be learned from experiences in other countries, and what practices can be transferred from one national context to another?
- how can national research programmes contribute to supporting sustainable development strategies at national and EU level?

The study mapped the key national actors involved in sustainable development and assessed the national research programmes in selected thematic areas in seven EU countries. Key issues which influence the thematic and organisational set-up of the national programmes include:

- the national research context and barriers to implementing sustainable development research;
- the existence of a national sustainable development strategy and its relationship to other policy areas, including research policy;
- the existence of umbrella, or framework programmes, and strategies.

These issues affect the ability of national programmes to address the multi- and trans-disciplinary research which forms the essential basis of research programmes in support of sustainable development. The situation in each country can partly be traced back to the national research and innovation systems in which they are embedded. The report examined best practice in general organisational terms, as well as in terms of targeting of specific individual thematic areas. It found that targeted programmes are considered important in giving new impulses to research areas and in building up new research communities that are able to deal with the challenges of sustainable development research issues. The umbrella programmes often find ways of overcoming institutional and organisational barriers to organising trans-disciplinary research, for example, by defining a concept for the umbrella programme that allows individual programmes and projects to be integrated. The project underlined the

potential for coordination of national research activities, especially in the areas of production and consumption, regional development and technological innovation.

The need to improve support for, and remove institutional barriers to, cross-cutting research has only recently been given official recognition in the UK. A report, in 2002, by the Policy Studies Institute for the Sustainable Development Research Network 'A New Agenda for UK Sustainable Development Research' provides a comprehensive analysis. The aim of the report is 'to provide a challenging agenda for funders and researchers alike to develop the institutional frameworks, research programmes and specific projects necessary to better equip the UK on the path to sustainable development.' The report takes the view that sustainable development research, given its strong policy orientation, is as much concerned with the integration, redefinition and use of existing knowledge as it is with the discovery of new theoretical concepts. It is not, therefore, an attempt to establish a new research discipline. Rather, a principal aim of a sustainable development research programme should be to demonstrate how and where existing research institutions and programmes should take sustainable development issues into account in the development of their current activities and their future plans and priorities. In particular, the PSI report describes the creation of the Research Councils UK Strategy Group, as a result of a review in 2001, with the aim of ensuring a more 'joined-up' approach. The Group is expected to develop a 10-15 year road map of opportunities for UK science. The Natural Environment Research Council has been given the lead in ensuring that sustainable development objectives are considered in shaping this road map and are properly integrated into all of the Research Councils' activities. The Group also has to consider 'ring-fencing' dedicated resources for the support of sustainable development research. Although these moves are designed to improve the strategic direction of sustainable development research, it is recognised as important to ensure that the gains are not frustrated at the operational level as a result of

appraisal and peer review processes continuing to be 'captured' by disciplinary interests. The IPTS project discussed above recognised this problem and posed the question of whether sustainable development research, involving a wide range of actors, requires different criteria for defining, assessing and evaluating research activities. It has also been recognised in the UK that there needs to be closer collaboration between government departments and agencies involved in sponsoring research and using the results in policy formulation and implementation. A UK Research Funders Forum has been proposed with the suggestion that it should be charged with a specific responsibility for ensuring effective support for sustainable development research. The Sustainable Development Research Network provides a voice for the research community in these deliberations.

This extended discussion of the international debate on the problems of designing sustainable development research programmes serves to emphasise that the identification of research needs has to be done in the context of whether mechanisms are available for their delivery. The important lesson from the above developments is that there is a need to consider how sustainable development research can find a place within existing funding structures in Ireland and, if necessary, how new structures or coordination arrangements might be designed. If this is not done, the research needs may well fall through the cracks in the system of mission-oriented funding bodies or be squeezed out by disciplinary priorities. The identification of means to overcome the barriers also has important implications for the effective integration of national research activities in Ireland on sustainable development with the sustainability theme in the EU's 6th Framework Programme of Research and Technological Development.

Finally, the role of S&T needs to encompass the arrangements for harnessing and using existing knowledge. In the presentation of the UK Energy White Paper in February 2003, the Energy Minister, Brian Wilson, cogently expressed the argument: 'Its time to get away from the perpetual R&D mentality and get the technology [of wind and wave power] into widespread commercial use'. Much information is already available and a priority for the role of S&T is to effect its capture and dissemination. For example, the EC has several activities that are directly relevant to the issues discussed in this statement. These include:

- the Action Plan on Environmental Technologies for Sustainable Development. This will survey promising technologies (with careful analysis of what constitutes 'promising') and analysis of barriers;
- the role of energy technologies in curbing carbon emissions and the impact of related policies (technology RTD support, environmental economics instruments, etc.) in accelerating energy technology substitutions towards a more carbon-free system;
- the production of Reference Documents of Best Available Techniques for pollution prevention and control in a wide range of industrial sectors.

In addition, the EC supports a wide variety of networks and information systems pertaining to S&T aspects of sustainable development. An important part of the role of S&T in Ireland is to ensure that the capability exists to take up and give practical application to the large fund of information available through effective networking in Europe.

6.0 The Way Ahead

The actions called for in this Statement are addressed to actors in various parts of the S&T and policy making systems. They will, in turn, need guidance on how best to deliver what is asked of them. For this, it will be useful to draw on the general lessons from elsewhere that we have discussed above in tackling the task of defining their strategies and objectives. In doing so, they will need to take account of any unique S&T features pertaining to Irish conditions while capitalising on that knowledge and experience. In order to enlighten the nature of this endeavour, the Council undertook three detailed case studies relating to sectors of great economic importance to Ireland. These are also sectors in which Ireland has significant S&T knowledge and experience in research and development. In each case, the studies sought to identify the issues that would arise from continuing with 'business as usual' and to examine the factors hindering and promoting sustainable development. They also considered the gaps in knowledge and the research needed to enhance the contribution of S&T to improving sustainability. The three case studies covered Renewable Energy, Cleaner Production and Agriculture and Forestry. They thus gave insight into both a particular industry and into cross-industry processes. The Council met small groups of people knowledgeable in the three areas and representative of the relevant S&T expertises as well as practitioners from the industries involved. The description of the case studies is given in Annex 1 of this Statement.

In elaborating on the role of S&T in a structured system of policy development, the next step is to develop a coherent framework of themes and associated principles. These would be analogous to and support the higher level themes and principles in the Comhar framework of principles for sustainable development. The focus of the S&T framework would be on enhancing the capability of the S&T system in responding to the challenges of developing and implementing policies on sustainable development. The policies themselves would be subject to testing against the Comhar principles.

7.0 Themes and Principles for the Role of S&T

From all of the inputs we have described above, the following themes and supporting principles have been formulated. Together, they constitute a framework for the attention of Government, public agencies and the S&T community. ICSTI proposes these principles as the outline of a brief to be given to key personnel in Government departments, science policy agencies, research institutions and research funding bodies, and, in particular, to the proposed new office of the Chief Science Adviser to the Government.

7.1 The importance of baseline research

We have to know where we are starting from and what the 'business as usual' trend line is likely to be if we are to have any chance of assessing the effectiveness of what we are doing or the optimum use of S&T to effect change. The Rural Environmental Protection Scheme (REPS) illustrates the point. This programme was launched without basic knowledge as to what the 'without REPS' starting point or future scenario would look like. It is now very difficult to assess its effectiveness in whole or in part. Similar issues arise in relation to other environmental improvement schemes. The proposed Programme of monitoring activities in the area of the maritime environment, referred to earlier, provides a good illustration of the approach needed.

Principle 1:

The extent to which relevant baseline information and the impacts of 'business-as-usual' are known in key environmental, economic and technological sectors should be assessed prior to deciding on actions, and any information gaps should be filled by appropriate research.

7.2 The importance of understanding underlying processes and causes

Environmental challenges derive from a web of interacting forces: certain economic activities yield impacts that produce a particular 'state of the environment', which in turn affects well being. This chain evokes, then, a management or policy response. If a sufficient understanding of the underlying scientific processes is not available, then it may happen that the wrong management and policy prescriptions will be adopted; the economy will suffer as resources are misapplied, and the environment will suffer because the most productive points at which to intervene were not known.

An example that emerged in the case studies was the relationship between afforestation and acidification of freshwater. Research has gradually yielded some insights regarding the geology, soil type and atmospheric chemistry which are likely to lead to problems in this regard, and this, in turn, allows a focusing of resources on the appropriate policy and management responses.

Principle 2:

The extent to which an understanding exists of the underlying dynamics in key areas of pressure - industry, transport, agriculture and forestry, energy, tourism - should be assessed, where necessary, and any measures needed to inform effective actions should be identified.

7.3 The importance of linking research in the natural and social sciences

Technology can yield information and opportunities that are not adopted or embraced because humans are not adequately informed, and/or because their value systems differ from those promoting the technologies. The case of Cleaner Production demonstrated the

imperative of addressing these connections. There are 'win-win' options - where simultaneously emissions are reduced and profits increased - that managers do not embrace. There appear to be several interacting factors for this, including the costs of time that managers have to allocate to exploring and implementing options, and concerns about the influence on product quality and timeliness. The difference of opinion between most scientists and active sectors of the public on the effects of thermal waste treatment (incineration) is another example where the 'fit' between science and society is uncomfortable.

Principle 3:

Research programmes should be structured to achieve the integration of natural and social sciences under an umbrella of sustainable development objectives.

7.4 The importance of integrating science, policy and economics

Technological innovations can provide self-financing opportunities to conserve environmental endowments. In practice, the extent to which their adoption proves to be financially and environmentally sustainable often depends, at least in part, on the quality of the policy designed to realise these opportunities. As noted earlier, there are many means to intervene - regulation, taxes and levies, emission trading, voluntary agreements, information, environmental infrastructural investment - that solely, or in some combination, create a virtuous circle where science, innovation, economy and environment all benefit.

Discussions on the combination of technologies and policies that would be most effective in countering freshwater eutrophication, or in stimulating the use of renewable energy sources, notably wind power, or the use of green technologies, soon come to the shared recognition that a firm basis for making rational decisions is lacking.

Principle 4:

Mechanisms should be developed to achieve better integration of science, policy and economic research on key issues, with a view to improving the rigour of sustainability assessment.

7.5 The importance of focusing research on key priorities or constraints

Research capacity is limited, and, therefore, needs to be concentrated where the results are likely to be of greatest value. The case study on renewable energy illustrated the point: a key constraint inhibiting the rapid expansion of wind power appears to be the inadequacy of the grid, or of our understanding as to how it can best be utilised. The potential benefits of better information would appear to justify some priority in R&D funding.

Principle 5:

The S&T opportunities for overcoming constraints inhibiting sustainable development in key areas should be analysed for practicability and value and relevant and appropriate research undertaken to allow the opportunities to be gained.

7.6 The importance of sustainability-proofing S&T advances

Not all innovations are environmentally and socially benign, and not all S&T advances overall well-being. This means that we need to somehow examine the wider sustainability implications of S&T advances generally as they unfold. It is important that such examination not be so bureaucratic that it stifles innovation and action. But it needs to happen early enough in the discovery cycle that, if necessary, efforts can be redirected in anticipation of potentially adverse effects. In other words, we need to work towards a

practical and operable application of the 'precautionary principle' as it applies to R&D.

Principle 6:

Mechanisms should be in place to assess the sustainability implications of key R&D programmes and projects, notably in the favoured areas of biotechnology and information technology and, where appropriate, applicants for research grants should be required to state how their research might contribute to sustainable development.

7.7 The importance of engaging the public's interests and insights in relation to S&T and sustainability

Abraham Lincoln observed that "with public support, nothing can fail. Without it, nothing can succeed". The sustainability S&T agenda provides an important opportunity to engage with the public's values and concerns and to begin a process of dialogue. In controversies and public debates surrounding issues with scientific content, dialogue is often hindered by the insistence of some parties that the matter must be discussed in a scientific manner, and the equally strong insistence of other parties that ethical and other value-based concerns should be taken account of. This is a particular priority in relation to the handling of the waste issue.

Principle 7:

Attention should be given, in formulating S&T advice and in research programmes, to public concerns surrounding issues involving S&T and to the protocols for engagement of the S&T community in public debates.

7.8 The importance of economies of scale in undertaking research and dissemination

Irish research capacities generally suffer in comparison with other advanced countries in terms of scale and scope. The Higher Education Authority's Programme for Research in Third Level Institutions (PRTLI) and the initiatives of Science Foundation Ireland (SFI) are aimed at overcoming that disadvantage, but much remains to be done. Typical research clusters are too limited as to staff and facilities, and too narrow in disciplinary focus, to be wholly effective. Providing further incentives for overcoming such diseconomies and such segregation should be a priority.

Principle 8:

The development of R&D clusters that are internationally competitive in their depth and range should be fostered and high levels of interdisciplinary cooperation and international networking should be encouraged.

7.9 The importance of linking S&T to the mission of major Government Departments

The Department of Enterprise, Trade and Employment has, as its mission, to 'deepen internal knowledge of the linkages between economic, social and environmental dimensions of the Department's work'. It is important that the sustainability brief of other Departments such as Agriculture, Education and Science, Communications, Marine and Natural Resources, Transport, and Tourism and Sport, be elaborated and that S&T helps achieve these missions. Mechanisms need to be put in place to facilitate the provision to policy-makers of relevant and timely scientific advice based on the best available evidence.

Principle 9:

The generation of S&T advice and the formulation of R&D programmes should contain explicit provision for the fulfilment of sustainable development objectives and should be integrated into the policy development process.

7.10 The importance of a global outlook for S&T in Ireland

It is natural that the main focus of attention for the role of S&T should be on equipping Ireland to move towards sustainable development within its own domain. But some of the adverse effects of current practices impact on other parts of the world. Some of these are, of course, addressed by improving on domestic practices, for example in relation to climate change. In turn, practices elsewhere have a spin-off effect: in Ireland, for example, economic migration to escape from conditions that could be tackled at source by S&T initiatives. The need to improve the S&T capacity of developing countries was acknowledged in the outcome of the 2002 WSSD in Johannesburg.

Principle 10:

The role of S&T in Ireland should encompass the stimulation of actions to assist developing countries in improving their S&T capacity.

Annex 1. Three Case Studies

In defining the contribution of science and technology to sustainable development, three case studies were developed from which to obtain general insight into the diverse constraints and opportunities that apply to them. The case studies covered the areas of renewable energy, agriculture and forestry, and clean technologies, giving insight into both a particular industry and into cross-industry processes. They are based on analysis and consultations with small groups of people knowledgeable in the three areas and representative of the relevant science and technology expertises as well as practitioners from the industries involved.

It was clear from this limited, though individually highly important selection of activities, that there are strong commonalities in the measures needed to overcome the constraints and seize the opportunities. Issues affecting the environment are currently the dominant focus of worldwide attention in sustainable development and this emphasis is reflected in the analysis. Nonetheless, the case studies do enable the identification of social and economic factors pervading the three areas examined and the identification of necessary actions.

1. Renewable Energy

Ireland's current annual energy requirement is over 13 million tonnes of oil equivalent. Currently, 98% of our energy needs are being met by burning fossil fuels such as oil, coal, gas, and peat; 85% of these fuels are imported. This puts Ireland as a leader amongst our European partners in fossil fuel importation. The continued consumption of fossil fuels is not sustainable due to their increasing cost and the quantities of greenhouse gases they produce.

Although Ireland is richly endowed with renewable energy resources i.e., wind, wave, biomass etc., only 2 % of the Irish annual total primary energy requirement and about 7 % of electricity generation is derived from renewable sources. Electricity generation from renewable sources is mainly from large-scale hydro, wind and landfill gas. Most

renewable fuel energy consumed in Ireland is from the industrial and domestic combustion of wood and other biomass.

Factors hindering sustainable energy

To date, the development and deployment of renewable energy technologies have faced a number of constraints in the Irish energy market, including,

- **Infrastructure** - much of the energy supply infrastructure, including electricity networks and gas pipelines, legislation, commercial contracts, and operational and planning procedures, were established for the facilitation of large, central power supplies and are often unsuited to the deployment of small, local renewable energy systems;
- **Costs** - the private costs of energy produced from renewable sources is generally greater than such costs of energy produced from fossil fuels. The costs of the environmental impacts associated with energy production from fossil fuels ('externalities') are not yet internalised into energy prices in Ireland, which makes the clear environmental benefits of renewable energy less apparent in the marketplace;
- **Technical issues** - technical challenges constraining the increased deployment of renewable energy include the remoteness of some energy sources from the areas of high energy demand and their intermittent nature;
- **Awareness and experience** - very often there is a lack of knowledge, experience and confidence with regard to renewable energy amongst policy and decision-makers and within the energy supply industry;
- **Deregulation issues** - there is currently a degree of uncertainty in the Irish energy markets due to deregulation, which may encourage investment in the more proven, conventional fossil-

fuelled plants and convince potential renewable energy developers to put projects on hold.

Factors promoting sustainable energy

There is little doubt that several renewable energy technologies could contribute much more to Ireland's primary energy requirement than is currently the case. Increasing the share of renewable sources in the energy balance enhances sustainability and will also help to improve the security of energy supply by reducing our dependence on imported energy sources. At present, there are a number of important drivers that should augment the use of renewable energy sources in the Irish market place. These drivers include:

- **Alternative Energy Requirement (AER)** - since 1994, the development of electricity generating capacity from renewable energy has been encouraged through a series of Government supported AER competitions. The objective of the AER is to increase the contribution of renewables in the overall electricity generating mix;

- **Green Paper on Sustainable Energy** - the 1999 Green Paper on Sustainable Energy, published by the Department of Public Enterprise, outlines policies and measures for energy efficiency and renewable energy to assist meeting Ireland's Kyoto target;

- **National Climate Change Strategy (NCCS)** - implementation of the NCCS, published in 2000, will open up further opportunities for renewable energy in the Irish market place. As part of the EU-wide effort to reduce GHG emissions, a pilot emissions trading scheme in carbon dioxide (CO2) is due to commence in January 2005. Specified emitters of CO2 will be given carbon allowances, with a requirement that their emissions are 'covered' by their allowances each year. They can buy and sell, so that those for whom it is very expensive to cut back keep emitting, and buy

allowances from those who can reduce emissions more cost-effectively. These transactions produce a price which, in turn, signals that it can be profitable to reduce emissions and sell the reduction onto the market. Such a signal creates an incentive to use renewables which do not emit carbon. A carbon tax is proposed by the Minister for Finance in 2004 which will have the same positive incentive effect for renewables;

- **Renewable Energy Research, Development & Demonstration (RER, D&D) and Grid Reinforcement programmes** - These are two programmes recently launched by Sustainable Energy Ireland (SEI). The focus of the RER, D&D programme is to stimulate deployment of renewable energies that are close to market and to assess and develop technologies that have prospects for the future. The objective of the Grid Reinforcement programme is to identify regions in which further grid infrastructure investment will contribute most to the uptake of grid-connected renewables, with a particular focus on wind power. The target will be to remove barriers to the deployment of renewable electricity generation in new areas and help stimulate growth of an Irish renewable electricity industry.

Research and S&T issues

The variable status and technological limitations of the main renewable energy technologies in Ireland can be summarised as follows:

(a) Wind Energy:

Wind energy is one of the most promising and cost-effective of the renewable technologies for electricity generation, and its deployment is now the fastest growing renewable energy technology worldwide. Although the technology is quite well developed, there is still scope for further technical development and cost-reduction, particularly in

rotor technology and variable speed generators and drives. Key issues for onshore wind are more likely to be creating the correct conditions (electrical network, market, social and land use planning) for the wider acceptance of the expanding deployment of wind energy.

(b) Biomass:

Biomass (vegetation and organic residues of biological origin) can be used to produce energy directly as heat or electricity or it can be converted into liquid or gaseous biofuels for use in transport. While previous attempts to establish Short Rotation Coppice systems in Ireland, have been unsuccessful, the true potential for biomass energy in Ireland has not been fully elucidated. The existing market for biomass in Ireland is dominated by the burning of wood for production and space heating purposes. However, biomass for process heat, electricity and combined heat and power has begun to attract increasing interest based on the experience and technological advancements made in some EU member states.

The carbon content of some waste streams from food and certain industrial processes, municipal solid waste, agricultural waste and sewage sludge can also be considered as biomass and have potential to be used as alternative energy sources. Technologies to produce electricity and heat from landfill sites are well established and the introduction of environmental legislation requires the collection of methane at landfill sites. Landfill gas is harnessed to produce electricity at five municipal landfill sites in Ireland.

(c) Solar (Active and Passive):

Active solar thermal systems convert solar radiation into thermal energy (heat), which can be used directly, or stored for later use. Particular key issues for this technology include improvements in performance and price reductions of heat storage systems, and cost reductions in the manufacture of collectors, generators and drives. From a policy perspective, Building Regulations should be amended so

that such systems could be encouraged during the design stage of proposed developments.

Passive solar design of buildings utilises the energy available from the sun (typically light, and possibly wind) to reduce the cost of heating, cooling and lighting. Key issues for this technology include the development of cross-sector integrated policies that would enlighten consumers, builders, architects, the construction industry, and local authority planners of the benefits in the development of more passive solar design.

(d) Wave and Tidal Energy:

While wave and tidal energy have enormous potential, technology is still at the development stage, and is not yet ready for commercial deployment. There are a number of fundamentally differing approaches to exploiting wave energy and, so, it can be difficult to identify generic R&D requirements. Funding for research on grid connection and interaction, energy storage, sub-sea cabling and strategies for operation and maintenance could benefit many ocean energy applications. In many countries, funding is directed towards supporting the R&D or demonstration projects.

Recommended Actions

In order to continue to enhance the deployment of renewable energy sources in the Irish energy market place into the future, the following steps require to be considered:

- Support research on 'market signalling' mechanisms - in the form of emissions trading and carbon taxes - and other incentive systems that provide a positive context for investors and consumers;
- Develop mechanisms and strategies above those currently

available for increased development and utilisation of renewable energy sources through national efforts and international co-operation, including the promotion of research, development and demonstration activities;

- Increase global efforts to mobilise and facilitate an increase in the flow of investment in mature renewable energy technologies and, at the same time, strengthen national capacity in the policy, institutional, technology, financing and commercialisation areas;
- Develop strategies for addressing issues, such as opportunities for decentralised energy networks, a more equitable basis for consumption, concerns about competition between food and biomass energy, water requirements for new biomass applications, public participation and concerns about waste-to-energy facilities and the visual impact of wind farms;
- Examine the linkages between the proposed Kyoto mechanisms and the NCCS mechanisms, focusing, in particular, on those mechanisms with the potential to further intensify renewable energy development;
- Ensure that national energy policies are linked to sustainable development policies and to actions consistent with international agreements.

Additional strategies may include: promoting international energy forums for dialogue on global issues, and linking centres of excellence into regional and international networks for the development and diffusion of renewable energy technologies which could include training of scientists, engineers and technicians in the development and utilisation of those technologies. These could also entail establishing regional networks for the exchange of experience in the development and application of renewable energy, research and development co-operation, including joint development projects, and sharing of testing and training facilities.

2. Cleaner Production

Cleaner production is the application of integrated preventive environmental strategies to manufacturing processes, products and services to increase overall efficiency and reduce risks to humans and the environment.

- For production processes: conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes.
- For products: reducing negative impacts along the life cycle of the product, from raw materials extraction to its ultimate disposal.
- For services: incorporating environmental concerns into designing and developing services.

The key difference between pollution control and cleaner production is one of timing. Pollution control is an after-the event, 'react and treat' approach. Cleaner production is a forward-looking 'anticipate and prevent' philosophy. Cleaner production (CP) brings economic, social, health, safety and environmental benefits. It is a 'win-win' strategy in that it protects the environment, the consumer and the worker while improving industrial efficiency, profitability and competitiveness.

Risks of Business as usual

In the last ten years, the development of cleaner production strategies has led to a paradigm shift in environmental management at the level of governments, business and financing institutions as well as local governments and communities, in some locations. Typically, the progressive mainstreaming of CP in a country has followed a strategy of moving from generating awareness to building the capacity of institutions. As a next logical step, with the help of key institutions, and by working in partnership, CP is demonstrated across various sectors to increase its acceptance. For a multiplier effect, information sharing mechanisms are then instituted by holding

seminars, publishing manuals, conducting training and operating websites. To develop an enabling framework, suitable financing mechanisms and policy instruments are devised. Based on ground level experience and consultations with important stakeholders, reforms are then undertaken to mainstream CP in the national policy and regulatory frameworks.

Apart from work done through the Environment Protection Agency's Cleaner Production Pilot Demonstration Programme and its Integrated Pollution Control (IPC) licensing system, little has been done in Ireland to promote CP in the different economic sectors. The majority of funding and grant aid goes towards production, with little being given to the other equally important areas. Consequently, there is a danger that Ireland will fall well behind other countries in this area. As business and consumers demand satisfactory environmental performance in addition to the traditional concerns of price, delivery and technical performance, Ireland must ensure that environmental concerns are satisfied.

The success of the limited work done to date is significant and underlines the potential for CP in Ireland if it is properly integrated into, and supported by, national policies. This calls for an integrated set of measures, with an adequate time horizon. A simple linear model of measures over 3-5 years will produce some limited success, but may not induce adequate change.

Factors hindering cleaner production

There have been several barriers to the promotion and adoption of CP, encompassing problems of communication, resistance to change, lack of appropriate demonstrations of CP to prove its benefits, inadequate training, a lack of CP-related information and problems in accessing cleaner technologies. Other critical barriers include the lack of financing and, more significantly, a lack of CP orientation in the national policy and regulatory framework.

Across all sectors of the economy, but particularly in the manufacturing sector, there is resistance to change. If the existing process delivers a good product there is a fear that any modifications to the raw material or energy inputs, or to the production process, may interfere with the quality of the final product.

Because of that, research and development needs to be directed to allowing different options to be tested without interfering with the existing production process. In the pharmaceutical sector, registration of processes with the US Food and Drug Administration may inhibit the scope for change even when the potential gains are obvious. Similar strictures apply to aspects of the aerospace sector. While difficult, these barriers should not be interpreted as insurmountable - there are cases in Ireland where significant process changes have been undertaken in these sectors, with economic and environmental benefits.

Factors promoting cleaner production

The introduction of Integrated Pollution Control (IPC) placed an onus on the industries with potential for serious pollution to examine and manage their operations. In anticipation of the Integrated Pollution Prevention and Control (IPPC) Directive, the IPC system has demanded a priority for avoidance or reduction of waste and emissions. Some significant improvements have been made by IPC-licensed industries where there has been a focus on the source of waste rather than on end-of-pipe treatment:

- a tennis ball manufacturing plant halved solvent usage by altering the order in which raw materials are introduced to the process; this had no impact on the quality of the final product;
- a laminated board manufacturer, in attempting to eliminate a pungent raw material which impacted on the local environment, succeeded in making a stronger, more durable product.

The IPC system has provided a stimulus for a large segment of industry in Ireland to improve its production processes. However, there is a lack of similar stimulus to activities outside the IPC Licensing scope.

There are other practical demonstrations in Ireland of the benefits of CP. In the first Cleaner Production programme, a chemical manufacturer separated a waste stream earlier in the production process and managed to convert it into a product that could be used as raw material elsewhere. The annual waste disposal bill of €380,000 was converted to a €45,000 annual revenue stream. Another participant, an ink manufacturer, moved to returnable ink containers, reducing packaging waste by 74 tonnes and saving €86,000 per year.

The significance of foreign direct investment to the Irish economy is well documented. In several cases, the corporate strategy of the parent company has imposed a prevention-oriented ethos on the local enterprise. In many instances, these enterprises are subject to IPC licensing, so it may be difficult to distinguish between the influence of the legislative imperative and the corporate influence. However, there are examples where these companies, driven by the philosophy of corporate responsibility, have encouraged other businesses to adopt a similar preventive approach. Such companies have the potential to act as role models for a sector and to influence change in supply chain networks.

The calibre of employees in Ireland is high. Many sectors employ a high proportion of graduates from the Institutes of Technology and the Universities. The capabilities of the local sites of multinational corporations have been recognized by many of these local sites becoming centres of excellence in their corporations, or lead manufacturing sites. This demonstrates that there is considerable human potential available as a resource, if given appropriate knowledge and direction. The Clean Technology Centre at Cork Institute of Technology has made a significant contribution; here, industrialists have been trained in cleaner production and have shared experiences.

Gaps in knowledge

Cleaner production seeks a better way of doing business by decoupling environmental impact from economic activity. Traditionally, there has been strongest emphasis on measuring or estimating environmental impact, e.g. water quality monitoring, which is the derivation of environmental condition indicators, and on measuring economic activity using financial indicators, e.g. trade statistics, census of industrial production. Less consideration has been given to the linkage between the flow of materials and energy through the economy. Examples of this have been the EPA's national waste and hazardous waste databases. Other examples have been the inventories of emissions of particular substances, e.g. non-methane volatile organic compounds (VOCs) or piloting of the application of material flow analysis. Such studies provide insights into the areas with the greatest potential for improvement at source. For example, the inventory of non-methane VOCs demonstrated the need to address an unexpected major source of these compounds.

Numerous studies have been published worldwide on possible improvement mechanisms, but less is known about their applicability in Ireland and the optimum path to encouraging their adoption and achieving continual improvement rather than intermittent change.

Science and technology issues

A characteristic of CP research is the need to undertake cross-disciplinary activities. Conventionally in Ireland, research has sought a well-defined, sharp focus. Such a narrow approach has brought benefits, but may not be appropriate to near-industry activities. Technical, managerial and organisational factors all need to be considered together, and in detail.

The opportunities to affect the productive sectors must be assessed. If manufacturing relies on direction from a foreign headquarters, there

may be little opportunity to influence proprietary process operations. In such cases, generic improvements may be more suitable for consideration.

Services are anticipated to become more important to the Irish economy. Consideration must be given to the manner that these can be delivered with minimal environmental impact, without merely redistributing the environmental burden to other parts of the globe.

Recommended Actions

Three levels of R&D can be defined: enterprise, sector and region or country. All three need to be integrated in order to ensure best results as no single initiative can deliver substantial change.

Research into sustainable development at regional or national level can consider a wide range of materials flows, incorporate services as well as manufacturing industries, and identify who are the gatekeepers, how issues emerge, and how the policy process addresses them. Technical assessment of the material and energy flows will identify the intensity of usage and the areas requiring prioritized attention. It will combine the traditional concern with wastes and emissions with the consumption of resources and associated transportation. Combining technical with organizational and policy issues will identify appropriate points for intervention and the associated tools.

Because competition constrains individual enterprises - expressed as unwillingness to share information and experience - research may be best focused on the sectoral level, identifying shared technical problems and appropriate incentives. Through benchmarking at sectoral level, the guidelines for individual firms can be set. Studies of actual performance are necessary to determine the gap between existing and potential best performance.

Ireland's continued economic development is highly dependent on foreign direct investment and certain sectors with potential for growth have already been identified and are being supported through research and development funding. Where specialist research centres already exist for these sectors, it is recommended that some of their funds be allocated to develop CP technologies in their area of influence. In addition, the need for the establishment of a world class facility dedicated to research into CP methods should be considered; this will deliver benefits across a range of sectors.

Research into a product's full range of components, including packaging and disposal, can help raise firms' awareness of producer responsibility. Based on investigation of products and product life cycles, research may usefully be focused on materials, and materials substitution, and opportunities may be identified for R&D or demonstration at enterprise level in materials engineering. Enhanced design methodologies can address many life-cycle issues simultaneously. Product design, in particular the environmental aspects of product design, needs to be emphasized more strongly.

The most effective economic drivers of sustainability-oriented R&D may not be grants, but larger-scale factors such as oil price, and "subtle" and "indirect" instruments. Background research into combined organisational, economic and cultural factors allows such instruments to be targeted effectively. Time horizons for research need to be established. There may be useful longer-horizon research to be done on "the factory of the future" and on the implications of the trend for products to grow over into services.

3. Agriculture and Forestry

Environmental sustainability is at the heart of animal and crop production. If crop and animal production is not managed in accordance with the principles of sustainable development, it may threaten the quality of the air, water and soil. Managers must be committed not only to the maintenance of productivity, but also to the production of high-quality, safe food and to the protection of the environment. The protection of the environment involves not only the air, water and soil, but also the maintenance of biodiversity in the context of the artificial ecosystems created by agricultural and forestry production.

Sustainability Issues

Agriculture is one of the principal contributors to water and air pollution. Excessive use of nitrogenous and phosphatic fertilisers have resulted in the eutrophication of surface waters. Natural concentrations of soluble phosphorus in surface waters are very low. Surface-runoff and losses from on-farm point sources can easily result in significant water pollution, despite the fact that, in most soils, the movement of phosphorus is severely restricted.

Greenhouse gas emissions from agricultural sources exacerbate our difficulties in achieving our commitments under the Kyoto protocol. Methane and nitrous oxide are important greenhouse gases. Although the quantities of each released into the atmosphere are less than those of carbon dioxide, their global warming potential is much greater than that of carbon dioxide, so that their potential impact on climate change is very significant. Nitrous oxide is emitted naturally from soils, but emissions are significantly increased through the application of nitrogenous fertilisers. Natural sources of methane include peatlands and wetlands. It is emitted in significant volumes by ruminant animals. Because of our high cattle population, this is a major source of this important greenhouse gas.

Ammonia is one of our most important air pollutants. While it is emitted from a variety of sources, a very high proportion is of agricultural origin, with the urine of farm animals being the main contributor. Ammonia is rapidly converted to ammonium in the atmosphere. Ammonium deposited on land surfaces, increases the rate of soil acidification.

Erosion is a natural process in all soils. However, management practices can greatly accelerate the rate of erosion. Erosion is particularly serious because soil must be considered, for practical purposes, a non-renewable resource.

Biodiversity is fundamental to the sustainability of the rural landscape and to the quality of life in the countryside. Emphasis on intensive agriculture inevitably threatens biodiversity on the farm. However, even within an intensive farming system, there is scope to support biodiversity without loss of productivity.

Forestry practice is much less intensive than modern agriculture. However, many of the sites selected in the past for afforestation are vulnerable either to acidification, or to runoff resulting in eutrophication or they are of particular interest by virtue of their natural or semi-natural biodiversity. Controls are now in place which confine grant aid for new plantations to better quality, and consequently less environmentally sensitive, land. Indicative areas for acid sensitivity have been proposed and approval for new plantations are based on laboratory analysis of surface waters to determine alkalinity levels. Strict controls are also in place to minimise the impact of forestry operations such as establishment, harvesting and fertilisation which, if not addressed, can affect erosion and eutrophication. In addition, current regulations and forest certification requirements have introduced measures which are designed to avoid, reduce or mitigate any environmental impacts on receptors such as landscape, surface waters, biodiversity, people, etc. These are far in excess of current requirements for agriculture.

Factors promoting or hindering sustainable development

Throughout the 1970s and 1980s, the competitiveness of the agriculture and the food industry was viewed purely in terms of price. Attitudes have changed. The importance of environmental sustainability is recognised, food quality and food safety are now seen as essential elements of competitiveness. In addition, increased emphasis on the extensification of agriculture, the Rural Environmental Protection Scheme and legislative measures designed to reduce pollution and to promote biodiversity have the potential to ease pressure on the environment.

In forestry, the single objective of timber production has given way to the recognition that the forest can fulfil many different functions in society and that managers have a responsibility to supply the goods and services demanded of the forest. Along with this attitude has grown the understanding of the interaction of the forest with the wider environment. The view of the plantation forest as an ecosystem has become stronger and, with it, a recognition of its influences, positive and negative on other ecosystems. There is now a clear acceptance of the responsibility of forest managers to protect aquatic, archaeological, biodiversity and landscape resources. There is also an acceptance of the need to manage forests according to the principles of sustainable development.

The difficulty we face in moving towards improved practice in agriculture is that some measures required to reduce the negative impacts of agriculture could seriously threaten both the economic sustainability of the sector and the social sustainability of rural communities. For a significant proportion of the farming community, the economic imperative for increased production remains, in addition to which, the legacy of previous practice will be felt for many years to come. This legacy includes the poor siting of animal production units, the residual effects of excessive fertilizer use and the difficulties of reducing atmospheric emissions.

In forestry, it is clear that the acceptance of the principles of sustainable forest management will result in forestry practice that is more in tune with the protection of the environment. These principles have been developed by Coillte (see 'Coillte's Forests - A Vital Resource') and criteria are applied in the form of social, environmental and economic indicators. Forest management practices are subject to certification by the Forestry Stewardship Council from a sustainability point of view.

While agricultural policy is directed at reducing the area of land in agriculture and at reducing overall production, the objective of current forest policy is to increase the area of forest land to almost twice the present area, by 2030. The challenge for the Forest Service is to achieve the high target levels of afforestation in an environmentally sensitive manner.

Science and technology issues

The principal limitations in the knowledge necessary to reduce the negative impacts of modern agriculture on the environment are in the areas of waste and nutrient management. Organic farm wastes represent a major hazard and their safe and efficient disposal remains a challenge, despite considerable progress. Unfortunately, in the past, livestock units were located without due consideration of the capacity of the soils of the region to absorb the wastes produced. The result is the ever-present hazard of surface run-off which can only be avoided with sensitive management.

The basic soil processes controlling the behaviour of organic matter and nutrients in soils are understood. What is lacking is the ability to apply the principles of soil chemistry and of hydrology on a national, regional, or even a farm scale. Due to inadequate background information, we cannot adequately assess the relative environmental impact of different sources of pollution, nor can we quantify variation in impacts in different parts of the country. The result is that the

application of regulations designed to control pollution is crude, perhaps ineffective, and inevitably open to charges of inequity.

Ironically, the efforts to control pollution and promote a more environmentally sustainable agriculture may prove to be a destabilising socio-economic influence. The blanket application of regulation may threaten the economic viability of agriculture in certain areas. This issue has received little attention to date. Addressing it requires integrating natural-scientific research and social-scientific research.

The problem with atmospheric emissions is similar. Most of the ammonia in our atmosphere comes from agricultural, largely animal, sources. We have a reasonable understanding of the factors which influence emissions of ammonia to the atmosphere, but lack detailed knowledge of mitigation procedures and their efficacy. In addition, due to the almost complete absence of nationwide monitoring data, we lack the information necessary to track trends in atmospheric concentrations.

We have in place instruments, such as the Rural Environmental Protection Scheme, which are designed to improve the quality of the rural environment. However, the scheme has not been adequately evaluated. This is particularly true in relation to biodiversity. Organisational constraints and the unduly narrow scope of REPs, limit the scheme's effectiveness. The number of full-time farmers is rapidly declining. We need to investigate the social implications of this trend. We need to acquire a better understanding of all the factors which underlie the sustainability of the rural economy. In essence, we need the knowledge to recreate a living countryside.

Forestry faces similar environmental problems to agriculture. While the scale of these problems and the potential magnitude of their impact is less, they are exacerbated by a legacy of poor site selection in the past. Even today, despite our increased understanding of ecosystem function, we have difficulty in identifying accurately sensitive sites and where sensitive sites have been afforested, to

regulate afforestation in order to produce the optimal mix of land uses for the protection and enhancement of the environment. Despite the greatly increased involvement of farmers in afforestation and in the forest industry, we have little understanding of the place of forestry in the rural economy and its potential impact on the sustainability of rural communities.

Gaps in knowledge

The gaps in our current knowledge are at two levels:

1. We lack basic environmental information in order to implement effective measures for the control of pollution without jeopardising the competitiveness of the agri-food and forestry sectors;

2. We need to establish mechanisms, designed to promote a higher level of interdisciplinary and inter-institutional interaction.

Improved Environmental Information

Although R&D spending in agriculture and forestry has significantly increased in recent years, we are suffering the consequences of years of neglect. Research has focused on studies which might be expected to give rise, in the short to medium term, to increases in productivity. Unfortunately, little attention has been given to the collection of basic monitoring information. The National Soil Survey was disbanded many years ago with little more than half of the country adequately covered. The network of precipitation chemistry monitoring stations is far below what is required for following trends in rural air quality. There is currently no network for the monitoring of ammonia in rural environments. These are deficiencies which are not easily made good. Although vitally important in the long term, they involve the

investments of significant resources for the collection of baseline information which will provide benefits to the economy in the medium, but probably not in the short term.

The quality of current research is good and the priorities identified valid in their own right. Unfortunately, without the essential baseline information, we cannot maximise the potential of the many well-conducted, well-resourced research studies which have been supported in recent years.

The socio-economic impact of environmental regulation on farm incomes and rural populations has not received adequate study. The viability of these communities is essential for the maintenance of sustainable agriculture.

Promoting inter-disciplinary and inter-institutional interaction

There are two issues here: firstly, we need to develop the capacity to view the sustainability of the countryside in a holistic manner. This involves improving the linkages between research and policy formulation; secondly, we need to maximise our resources for research and technological development.

The control of agricultural pollution cannot be viewed solely from an environmental perspective without reference to its impact on economic and social sustainability. Similarly, the development of sustainable forest management must be managed in the context of a living countryside.

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ICSTI Statements (1997-2004)*

Title of Statement	Date of Publication
Nanotechnology	July 2004
Sustainable Development in Ireland: The Role of Science & Technology	May 2004
National Code of Practice for Intellectual Property from Publicly Funded Research	Jan. 2004
EU Debate on the Role of Fundamental Research	Nov. 2003
A Comparison of Starting Salaries for Science Graduates and Engineers	Aug. 2003
State Funding Priorities for 2004	July 2003
Utilising Intellectual Property for Competitive Advantage	Feb. 2003
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Measuring and Evaluating Research	Aug. 2002
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Commercialisation of Publicly Funded Research	Feb. 2001
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Title of Statement	Date of Publication
Public Sector Research and Technology Services for Innovation in Enterprises	Sept. 1999
Technology Foresight Ireland1	April 1999
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State Expenditure Priorities for 1998	Sept. 1997

* *A CD of ICSTI Statements published between 1997 and 2001 is available from the ICSTI Secretariat.*

1 *A suite of nine reports comprising an ICSTI overview and eight individual reports from expert panels established in the following areas: Chemicals & Pharmaceuticals; Information & Communications Technologies; Health & Manufacturing Processes; Health & Life Sciences; Natural Resources (Agri-Food, Marine, Forestry); Energy; Transport & Logistics; Construction & Infrastructure.*