CABINET OFFICE

performance and innovation unit

Resource productivity: making more with less

CONTENTS

FOREWORD BY THE PRIME MINISTER

The last 50 years have seen the transformation of the developed world's economies – from the shortages of the post-war period to the high-tech globalisation of the 21st century. This transformation has brought with it many benefits that are now taken for granted, but that were little more than possibilities 50 years ago. But it has also brought with it new challenges and pressures.

One of the greatest of these is the challenge of achieving continued economic growth without the unacceptable costs of environmental and social degradation. That was why I asked the Performance and Innovation Unit (PIU) to investigate how Government could help to shift our economy onto a more sustainable footing – how we could increase resource productivity, producing more goods and services with fewer inputs of materials and energy, and with less pollution and waste.

The PIU report clearly shows that greater resource productivity could offer significant benefits not only to the environment but also to business. The PIU argues that new methods that make use of fewer resources and minimise waste point the way to a more sustainable economy in the future.

The PIU has researched the issues in considerable depth, and has identified some areas where further action is needed. These conclusions are offered not as a statement of Government policy, but rather as a contribution to the debate. The recommendations made in the PIU report show how we could build on existing policy to improve our resource productivity. These represent only a first step. They will need to be followed up in consultation with experts and colleagues in the UK and overseas.

The Government recognises that the issues raised in this report are important. We are fully committed to the report's implementation. The promise is clear: that instead of seeing the environment and the economy as two opposing interests, an agenda focused on resource productivity can deliver high levels of growth and employment alongside effective environmental protection for generations to come.

Tony Blair
Prime Minister

MAIN POINTS OF THE REPORT

- Improving resource productivity has been identified by Government as "a key to change" in achieving sustainable development – a primary goal of Government policy. Resource productivity measures the efficiency of the economy in generating output without using up natural resources – including the resource provided by the capacity of the environment to absorb our waste and pollution. Some commentators have suggested that over the next few decades, output could double while natural resource use is halved if new methods are used, though this claim requires further investigation.
- Increased resource productivity has been a key feature of the economic growth of the last 100 years. However, environmental pressures, especially climate change, will require continuing and perhaps accelerating progress. Innovation will need to play a key role.
- Action to improve resource productivity can help to meet economic and environmental objectives at the same time. Improving resource productivity will make less binding the constraints on growth imposed by environmental limits – such as climate change – as well as helping the economy become more efficient and improving quality of life.
- Business and households should play lead roles in making more productive use of natural resources. However, there is also an important role for Government in setting the right incentives, providing an example and overcoming barriers – such as information deficiencies, limited access to finance, skills shortfalls and other factors.
- The resource productivity agenda remains at an early stage of development, and many of the links between the economy and natural resources remain imperfectly understood. However, a number of practical measures could be taken now, including:
  - sending clear signals about the way in which the economy will need to develop over the long term;
  - encouraging companies to report on their resource use as well as traditional measures of company performance;
  - using innovation policy, Government procurement and education more effectively to bring about improvements in resource productivity;
  - improving our understanding of the role of resources in the economy, and what contribution resource productivity might make to policy analysis;
  - developing better indicators of resource productivity.
- Overall responsibility for taking forward this report will rest with DEFRA, in close consultation with DTI, HM Treasury and other national, regional and devolved Government bodies. It will also be important to liaise closely with international initiatives on resource productivity.

EXECUTIVE SUMMARY

The challenge of sustainable development and prosperity

Sustainable development is about meeting four objectives at the same time:

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- prudent use of natural resources; and
- maintenance of high and stable levels of economic growth and employment.

The UK's Sustainable Development Strategy was published in 1999. The strategy sets out action being taken to meet the four objectives, focusing on a number of key principles such as taking a long-term perspective and taking account of costs and benefits. Progress towards sustainable development is measured against a series of indicators, which are to be monitored in an annual report.

On a global scale, the extent of world poverty makes sustainable development a huge challenge. At national level, the scale of the challenge for the UK should not be underestimated, even though considerable progress has already been made – for example, in reducing our emissions of carbon dioxide, the main greenhouse gas, while the economy has continued to grow at a steady rate.

Although considerable progress has been made, day-to-day activity creates large volumes of waste and pollution. Our environment is able to absorb some of this waste and pollution with relatively little impact. But as volumes of waste and pollution increase, we are approaching some environmental limits in terms of the degree of environmental degradation that can be endured. Some commentators have suggested that the world should be aiming to double output while halving natural resource use, though this requires further investigation. Perhaps the most pressing problem is that of climate change, where even though improvements have been made by the UK and others, there are major concerns about the impact of continuing to emit greenhouse gases at anything like the current global rate.

Short-term barriers and long-term trade-offs

There are actions which could be taken now to help deliver sustainable development. Many of these would cost very little, and might even save money – for example, by improving the energy efficiency of our homes and helping to cut energy bills.

But there are barriers that are preventing these from being undertaken. These include: the low priority attached to sustainable development relative to other, seemingly more pressing, needs; lack of information about what could be done; and limited access to the capital and skills that would be needed to take action. There are also actions that should be taken, but for which there is no incentive because prices do not reflect the costs our actions impose on society as a whole.

Looking to the longer term, we can expect to face many trade-offs between the different objectives of sustainable development. For example, some environmental problems – such as climate change, limits on the availability of freshwater resources and falling fish stocks – limit the extent to which depletion of natural and environmental resources can fuel economic growth. Unless action is taken, we will face some very difficult choices.

Improving resource productivity can help deliver sustainable prosperity

Resource productivity measures the efficiency with which the economy uses energy and materials (the natural resource inputs needed to achieve a given economic output). If the definition of natural resources includes pollution sinks – the capacity of the atmosphere, the land area and the world's oceans and rivers to absorb waste and pollution – resource productivity also measures the economy's ability to produce goods and services relative to its environmental impacts. This wider measure is more useful to policy-makers, because our most pressing concerns relate to the way we are using up the resource provided by pollution sinks, rather than to the scarcity of resource inputs.

Resource productivity can deliver benefits to the economy and society

Where there are environmental limits, improvements in resource productivity allow us to combine economic growth with protecting the environment. Other potential benefits from resource productivity improvements are the following:

- Where natural resources are important inputs to economic activity, improving resource productivity will have a key role in cutting costs, improving overall productivity and reducing waste and pollution.
- Resource productivity improvements will contribute to environmental goals, helping to achieve improvements in quality-of-life that are not picked up in economic measures.
- Improving resource productivity and the quality of the environment will often have a beneficial impact on the productivity of labour and of capital.

Resource productivity can save money for businesses and households

Improving resource productivity is not just important to policy-makers. There are many examples of businesses and households that have improved the efficiency with which they use natural resources, cutting down on environmental damage at the same time as reducing their own costs and improving their own financial performance. Within the business world there is growing recognition that good environmental and social performance, as well as financial results, is important for the long-term value and success of a business. Resource productivity improvements can play an important part in meeting this agenda, and improving corporate social responsibility.

Innovation will be key to delivering resource productivity

Improving resource productivity will require that we invest in new ideas, new technologies and new processes that enable us to create output and value while respecting environmental limits.

But it is not just technological innovation that is required. There is likely to be a need for new institutions, new infrastructures and a shift in attitudes that will facilitate the sorts of changes we need to make.

Using resource productivity as a conceptual tool

Businesses and households will take many of the actions leading to improved resource productivity. But Government has a prime responsibility for setting the policy framework within which this happens. This will include providing incentives for resource productivity, bridging information gaps and acting as an exemplar in its own procurement policies.

Resource productivity does not in itself provide an analytical tool. But it can help us to think about what types of policy will work best in helping adapt the economy to environmental constraints, and how the interaction of public policy and private decisions can minimise the risks to the environment. The Performance and Innovation Unit (PIU) review of energy policy provides an example of this sort of approach in action.

Practical immediate steps can build on existing achievements

We need to improve our measurement of resource productivity and our understanding of the issues, including the potential scale of the challenges we face over the next 50 years. In the meantime, there are a number of areas identified in the report where the UK could take further action now, including the following:

Delivering greater long-term clarity

There will always be uncertainty about the long term. But Government can reduce the uncertainty for decision-makers by setting indicative targets for long-term improvements in resource productivity and reductions in waste and pollution. Possible targets should be investigated and – where appropriate – put in place as soon as possible.

Building on existing use of market instruments

Government's Statement of Intent on environmental taxation sets a clear framework for using the tax system to improve resource productivity. There is scope for the principles in the statement to form the basis for application of other economic instruments, such as tradable permit schemes.

Targeting innovation policy to improve resource productivity

Much of innovation policy will help to encourage resource productive innovation. But the market is unlikely to deliver on its own, and there will be a key role for Government measures to target innovation on resource productivity.

Reflecting sustainable development in procurement policy

There is considerable scope for Government procurement to reflect the goals of sustainable development. Action on recycled paper and on sustainable timber provides a good basis. But much more can be done and Government departments need to be held accountable for their performance in this area.

Encouraging corporate social responsibility

Many companies already recognise the importance of their social and environmental reputation, and the need to be transparent and accountable against a triple bottom line. But others are lagging behind. Government can raise awareness, disseminate good practice and encourage take-up of voluntary guidelines. At the same time, Government should consider the extent to which voluntary measures, and the proposals from the Company Law Review, will lead to a level of reporting which meets its objectives.

Focusing attention on small businesses

Small businesses face particular problems and barriers in improving resource productivity. They lack the information, expertise and support available to larger firms. There is a case for developing a sustainable development approach for small businesses, built around action to improve resource productivity.

Delivering cultural change

Improving resource productivity is likely to require major changes in the long term. It will be important for Government to step up the process of engaging, educating and preparing society for these changes.

Action also needs to be taken at the international level

In taking forward these recommendations, and preparing ourselves for the more significant changes likely to be needed in the future, it will be important that we consult widely with colleagues in the international community. The OECD and European Commission have major initiatives in place to analyse resource productivity, and the world will be increasingly paying attention to the issues in advance of the World Summit on Sustainable Development in September 2002. Dissemination of the issues will be important, so that the UK can help others achieve sustainable development.

Implementation and next steps

DEFRA will have lead responsibility in considering the recommendations made in this report, in close consultation with DTI, HM Treasury and other departments. A steering group will be established to oversee progress, and officials will be tasked with taking forward specific initiatives. The network of "Green Ministers" will be responsible for disseminating good practice around Government. It will also be important to work with other national, regional and devolved Government bodies.

INTRODUCTION

What this report is about

This report is intended to support and inform the development of the Government's long-term programme for sustainable development in the UK.

Sustainable development requires that progress be made simultaneously in terms of economic, social and environmental objectives. No one can be sure what kind of world will develop over the coming decades, but we do know that we need to plan now to create a prosperous economy and a decent society and environment. And we need to take action now to change our use of energy and materials, in order to avoid serious environmental problems that could disrupt the climate, make our energy supplies less secure, and damage our quality of life and competitiveness.

Resource productivity measures the efficiency with which we use energy and materials throughout the economy – in power generation, manufacturing, services, households and the built environment as a whole. By improving resource productivity, we can cut costs and generate more value from finite stocks of non-renewable resource inputs.

But the definition of natural resources that is most relevant to policy-makers covers more than simply resource inputs. The type of natural resource most under threat throughout the world and in the UK is the capacity of the environment to absorb all types of pollution. The resource provided by these pollution sinks is gradually being used up. This is true both at a local/regional level (for example, the availability of fertile soil in arid regions; availability of landfill sites in heavily populated regions) and at international level (for example, the capacity of the atmosphere to accumulate greenhouse gases without significant adverse impacts through climate change). It is this pressure that provides the greatest imperative today to tackle resource productivity, so that we can deliver economic progress alongside environmental protection and improvement.

Of course, improvements in resource productivity will not in themselves deliver sustainable development. Resource productivity is about the economic and environmental elements of sustainable development, with little applicability to the social aspects. Even within the economic/environmental axis, assessing policy options in the light of resource productivity will be a complement, not a substitute for proven and successful techniques and policy instruments. These include identification of situations where the market fails to deliver desirable outcomes, and action to make polluters pay the price for the costs their activities impose on society. And more specific still, the concept of resource productivity is likely to be limited in the way in which it can be applied to issues of toxicity or individual hazards.

But resource productivity does provide an additional lens through which to view the policy challenges and opportunities. And resource productivity improvements have been identified as "a key to change" in the Government's Strategy for Sustainable

Development,[1] as well as providing a means by which businesses and households can become more efficient and cut costs. This report:

- puts the improvements required in resource productivity in the context of the challenges we face under sustainable development;
- shows how to reintroduce natural resources into the concept of productivity and how to derive policy implications from this;
- explains what resource productivity is, and why it matters;
- highlights areas where we need to improve our understanding of the role of natural resources in the economy; and
- suggests some early action that could be taken to encourage improvements in resource productivity.

The origin and remit of the study

The Performance and Innovation Unit (PIU, see Annex A) study on resource productivity started in January 2001. There were three strands to the original study: resource productivity, energy productivity and renewable energy. The work on energy productivity and renewable energy was subsequently taken into the review of energy policy conducted for the Government by the PIU. However, this work has been used to inform conclusions on resource productivity more generally.

Subsequent to the removal of the work on energy productivity and renewable energy, the PIU team was asked to address three main goals:

- to contribute to shaping a coherent policy framework that better integrates resource productivity with the other aspects of sustainable development;
- to define the specific policy instruments that Government and the EU can use to encourage businesses and consumers to increase resource productivity, including market-led approaches; and
- to develop a coherent way of thinking about resource productivity issues, allowing the UK to play a leading role in determining how to address these issues in the EU and globally: contributing to the Prime Minister's "advancing sustainable development in the modern European economy" initiative.

How the project was carried out

A multi-disciplinary team, comprising a mix of civil servants and secondees from outside Whitehall, was assembled in January 2001 (details in Annex B). The team began by developing a clear understanding of what resource productivity means, and how it is linked to economic and environmental policy and objectives. The team then went on to consider how the concept of resource productivity can help to inform policy-making, and how resource productivity improvements might be delivered.

In carrying out the study, the project team has drawn on the expertise of the project's Advisory Group, made up of representatives and stakeholders from inside and outside Government. This group was chaired by Baroness Symons of Vernham Dean, Minister for Trade at the Foreign and Commonwealth Office (FCO) and at the Department of Trade and Industry (DTI).

[1] DETR, "A Better Quality of Life – A Strategy for Sustainable Development for the United Kingdom", CM 4345 (1999), available at http://www.defra.gov.uk/environment/sustainable/index.htm.

The project team also consulted a wide variety of other experts and stakeholders. These included Government departments, offices and agencies; industry groups; environmental non-governmental organisations (NGOs); regional and devolved bodies; and independent experts, academics and consultants. Each of the meetings, workshops and seminars held with these groups helped the project team to understand the issues of principle and of practice that are important in the context of resource productivity. Full details of those consulted are available from the PIU.

Structure of the report

The report is structured as follows:

- Chapter 1 sets out the policy challenge faced by the UK in achieving sustainable development, and identifies some of the barriers to progress;
- Chapter 2 explains in greater depth what resource productivity is, and how improvements in resource productivity could help to deliver economic and environmental benefits, easing trade-offs and promoting synergies;
- Chapter 3 addresses the role of natural resources in the economy and the measurement of resource productivity, and makes recommendations for research and analysis to improve our understanding;
- Chapter 4 identifies what might need to be done when our understanding of the issues has improved, and makes recommendations for actions that could be carried out now to help improve resource productivity;
- Chapter 5 summarises the full set of recommendations in the report, and suggests how these should be taken forward, and how this report should be used to engage with other experts and work programmes in the UK and internationally.

Annexes provide further detail on the processes behind the preparation of the report, expanded discussion of some specific initiatives and a deeper perspective on the theoretical underpinnings of resource productivity.

1. THE POLICY CHALLENGE AND BARRIERS TO PROGRESS

Summary

- Achieving sustainable development poses significant challenges for the UK and for the whole world.
- The issue of climate change perhaps best illustrates the scale of the challenge. The 2050 greenhouse gas emission reduction target proposed by the Royal Commission on Environmental Pollution lies well beyond the range of business-as-usual projections.
- The UK has responded to the challenge through its Sustainable Development Strategy, and other strategies targeted at particular problems. There is an opportunity for the UK to use these initiatives to lead the global response to the sustainable development challenge.
- There are, however, many barriers to taking up measures that will help deliver sustainable development. These seem to be particularly acute for the small business sector.
- In the longer term, the UK potentially faces some difficult trade-offs between economic and environmental objectives. But early action to deliver structural change in the way in which we carry out our economic activity could turn these trade-offs into synergies.

1.1 Sustainable development and resource productivity

A focus on resource productivity can be one of the keys to achieving sustainable development, which is a primary goal of the UK Government.[2] In order to understand how the resource productivity lens can help, however, it is necessary to grasp the scale of the sustainable development challenge. At the heart of sustainable development is the simple idea of ensuring a better quality of life for everyone, now and for generations to come. This means meeting four objectives at the same time, in the UK and the world as a whole:

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- prudent use of natural resources; and
- maintenance of high and stable levels of economic growth and employment.

Measuring sustainable development is difficult, as there is no single indicator that captures the full range of objectives. The UK Government measures sustainable development using 15 headline indicators and 147 core indicators at national level, in addition to regional and local indicators.[3] But what is clear is that sustainable development presents a severe policy challenge: to find ways of achieving simultaneously economic growth, social progress and environmental protection and improvement, taking into account the longer-term (affecting different generations) implications of decisions.

1.2 The scale of the challenge

Sustainable development is an issue for the whole world

At a global scale, the challenge of sustainable development is staggering. One-in-five of the world's population – over a billion people – have to survive on incomes of less than US$1 per day. More women die from pregnancy in a week in India, than in the whole of Europe in a year. One-in-four adults in the developing world are unable to read or write. And it is developing countries – those least able to cope – that are likely to suffer most from the effects of regional and global environmental problems.[4]

The UK does not have problems on this scale. But the UK does have a role to play in helping the rest of the world move towards sustainable development. And it would be wrong to assume that the challenge in the UK is not a significant one, particularly over the long-term time horizon considered in this study. The UK's Sustainable Development Strategy summarises the scale of the challenge in this way:[5]

"We have to find a new way forward. We need greater prosperity with less environmental damage. We need to improve the efficiency with which we use resources. We need thriving cities, towns and villages based on strong economies, good access to services and attractive and safe surroundings. And we need international co-operation to overcome environmental problems, to allow trade to flourish and to help the world's poorest people as we move towards a more global society."

[2] DETR (1999), op cit.
[3] Details available in DETR, "Quality of Life Counts: Indicators for a Strategy for Sustainable Development for the United Kingdom: a Baseline Assessment" (1999a), available at http://www.sustainable-development.gov.uk/indicators/headline/h2.htm.
[4] All statistics taken from DFID, "Eliminating World Poverty: Making Globalisation Work for the Poor: White Paper on International Development", CM 5006 (2000).
[5] Chapter 1, DETR (1999), op cit.

It is important to realise that sustainable development is not about slowing down economic growth so that we can protect the environment. Perhaps because responsibility for sustainable development typically lies within environment ministries,[6] this is often how it is caricatured. But in reality, sustainable development is just as much concerned with economic and social progress as it is with environmental improvement. In the UK, for example, economic growth remains vital for a better quality of life: for education, healthcare and housing, to tackle poverty and social exclusion, and to improve standards of living through better goods and services.

Economic progress and environmental protection

Sustainable development focuses attention on the interactions between economic progress and environmental protection. In the past, economic activity tended to mean more pollution and greater use of resources. The first report[7] from the Advisory Committee on Consumer Products and the Environment (ACCPE) stated that:

"The significance of goods and services for the environment, and for human health and well-being, has been growing sharply… because economic development in the 20th century was accompanied by more and more personal needs and aspirations being met through the direct consumption of goods, often of short-life duration. This adds up to greater consumption of materials and resources used in manufacture, new impacts from production and distribution, and a huge rise in the impacts which come from the consumer's use and disposal of the goods."

We have had to spend considerable sums of money to clean up the mess. A damaged environment impairs quality of life and, at worst, may threaten long-term economic growth – for example, as a result of climate change. And too many people have been left behind, excluded from the benefits of development but often suffering from the side effects.

Quantifying the scale of the challenge is not easy, as reflected in the UK Government's commitment to monitor progress across the whole set of 15 headline indicators. One attempt that has been made is in the so-called "Factor Four" literature associated with Amory Lovins and others.[8] "Factor Four" calls for a halving in global resource use. It claims a four-fold increase in eco-efficiency is required on a global scale. What this means in practice is a quadrupling of resource productivity, for example through doubling wealth while halving resource use. The "Factor Four" literature has been very successful in raising awareness among policy-makers and business people of the potential environmental and economic importance of improving resource productivity. However, much more work is needed to establish the scale of the challenges we face and of the resource productivity improvements required. And it is likely that greater progress will be required in some areas, such as climate change, than others.

Climate change illustrates the scale of the global challenge

At a more detailed level, the issues surrounding climate change provide perhaps the most pressing and graphic example of the scale of the challenge. Whatever happens next in terms of greenhouse gas emission reductions, the impacts of climate change caused by those emissions are likely to have "far-reaching effects on all aspects of the world's environment, economy and society".[9] Action to reduce the greenhouse gas

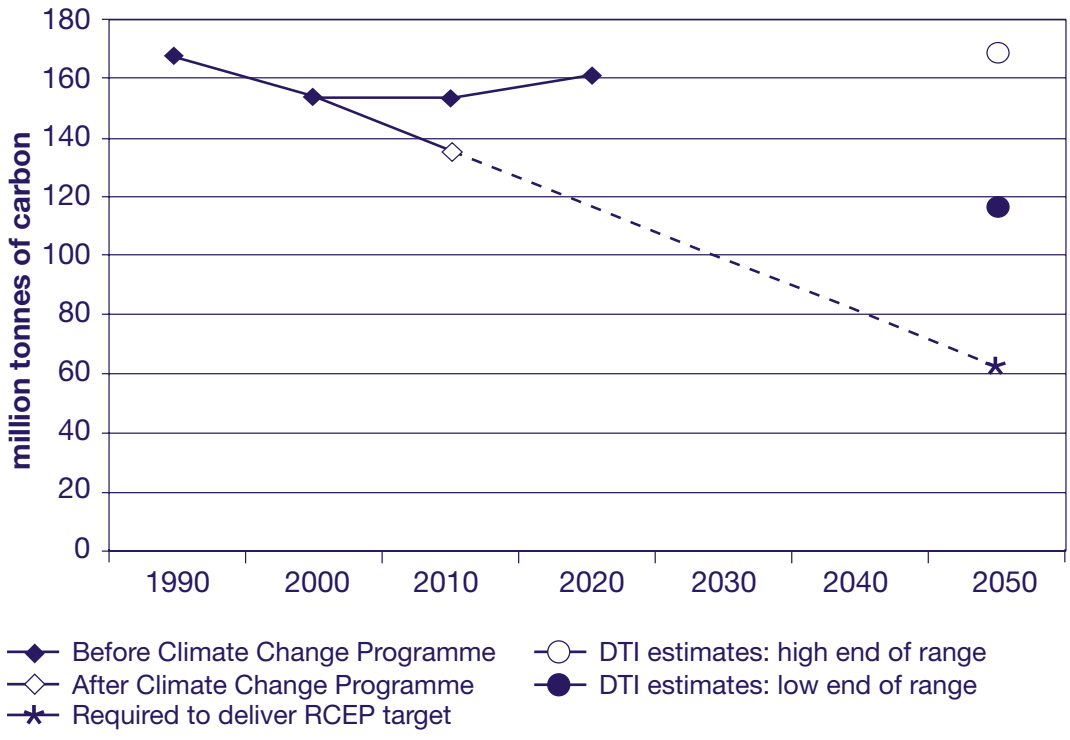
[6] Lead responsibility for sustainable development in the UK lies with the Department for the Environment, Food and Rural Affairs (DEFRA).
[7] ACCPE, "Choosing Green – Towards More Sustainable Goods and Services", first report (2000), available at http://www.defra.gov.uk/environment/consumerprod/accpe/report01/index.htm.
[8] See, for example, Hawken, P, Lovins, AB and Lovins, LH, "Natural Capitalism – The Next Industrial Revolution", Earthscan (1999).
[9] DETR, "Climate Change – The UK Programme", CM 4913 (2000b).

emissions that cause climate change has been identified by the OECD as one of its "red light" environmental issues. Red light issues, according to the OECD, require urgent action and step changes in the way we use resources and create pollution (other OECD red light issues include agricultural pollution, over-fishing and municipal waste generation).[10]

Climate change is an international issue, and the UK has accepted targets under the international climate change negotiations governed by the United Nations Framework Convention on Climate Change (UNFCCC). The single most significant document agreed in these negotiations to date has been the Kyoto Protocol.[11] This will enter into force when it is ratified by 55 countries, including developed countries accounting for at least 55% of developed countries' carbon dioxide emissions in 1990. When the Protocol enters into force, the UK will be legally bound to reduce emissions to 12.5% below 1990 levels by the commitment period of 2008–12. In addition, the UK has a domestic goal of reducing emissions of carbon dioxide – the main greenhouse gas – to 20% below 1990 levels by 2010.

The Performance and Innovation Unit (PIU) review of energy policy is considering the extent of the long-term challenge faced by the UK in seeking to reduce greenhouse gas emissions. A key part of the review will be an assessment of the recent proposals set out by

Figure 1: Carbon dioxide emission projections, baseline estimates and possible targets over the next 50 years[12]



[10] OECD, "Policy Brief – A New Strategy for the Environment" (2001a).
[11] UNFCCC, "Kyoto Protocol to the Framework Convention on Climate Change" (1997).
[12] Data for the "pre- and post-CCP" lines is taken from DETR (2000b), op cit. Other data is taken from "Long-Term Reductions in Greenhouse Gas Emissions in the UK – preliminary report of work in progress of an inter-Department Analysts' Group", an internal paper produced by DTI in March 2001, using analysis based on the DTI energy model. Business as usual baseline projections over a 50-year period are subject to considerable uncertainty. The Analysts' Group has therefore explored a range of different assumptions and projected forward on various bases. The range presented reflects the full extent of the results produced.

the Royal Commission on Environmental Pollution (RCEP). The RCEP has anticipated that the UK will need to reduce its emissions by 60% by 2050, as part of the global effort.[13] This is consistent with long-term estimates produced by the Inter-Governmental Panel on Climate Change, though the exact scale of the challenge faced by the UK will of course be subject to emerging climate change science, and to international negotiation.

Figure 1 shows that the RCEP proposal sets a significant challenge for the UK. The solid lines illustrate projected carbon dioxide emissions in the UK before and after the UK's Climate Change Programme (CCP) – the UK's response to the climate change challenge – is taken into account. The pre-CCP trend shows an upturn in emissions in the middle of this decade. The CCP has reversed that trend through a comprehensive programme of measures. But the recent trend will need to continue for the next five decades if we are to achieve the RCEP target (dotted line), and this can be contrasted with the range of baseline projections estimated by DTI.[14] These issues will be considered further in the PIU review of energy policy.

The UK faces other challenges

This report is not just about the use of fossil fuels and the threat of climate change. As the OECD indicators[15] illustrate, there are many significant challenges to be faced up to in relation to resource use and resource productivity. One of the most significant of these facing the UK – on a very different scale to the problems of climate change – is waste generation.

The UK is signed up to a large number of targets associated with waste arisings and landfill, many of which have been adopted across the whole of the European Union.[16] Most significant among these is the EU Landfill Directive, which sets targets for landfill (particularly relating to biodegradable municipal waste) out to 2020. Some of the targets also come from UK legislation, and the particular pressures facing the UK in terms of availability of landfill sites in highly populated areas.[17] Tackling waste can also help to reduce pressure on virgin materials, by encouraging the re-use and recycling of existing products.

England, Wales, Scotland and Northern Ireland are currently implementing their waste strategies in response to the targets and regulations faced. One early target illustrates the scale of the challenge. As part of its waste strategy, England and Wales has a series of targets for recycling or composting household waste.[18] These build from current levels to a target requiring that 33% of household waste should be recycled or composted by 2015. An interim target is to hit 25% recycling/composting rates by 2005/06. The scale of the challenge is

[13] Royal Commission on Environmental Pollution (RCEP), "Energy – the Changing Climate", CM 4794 (2000).

[14] Another illustration of the extent of the challenge comes from estimates of the carbon tax that would be needed to stabilise international greenhouse gas emissions. One recent estimate using a macro-econometric model suggests that a global carbon tax set at US$750 per tonne of carbon would be needed in order to stabilise emissions at 30% below 1990 levels by 2030 (Mabey, N, Hall, S, Smith, C and Gupta, S, "Argument in the Greenhouse – The International Economics of Controlling Global Warming", Routledge (1997)). This is a relatively high estimate compared with others in the literature, but does illustrate the difficulties of decoupling emissions from economic growth without a structural change in the economy.

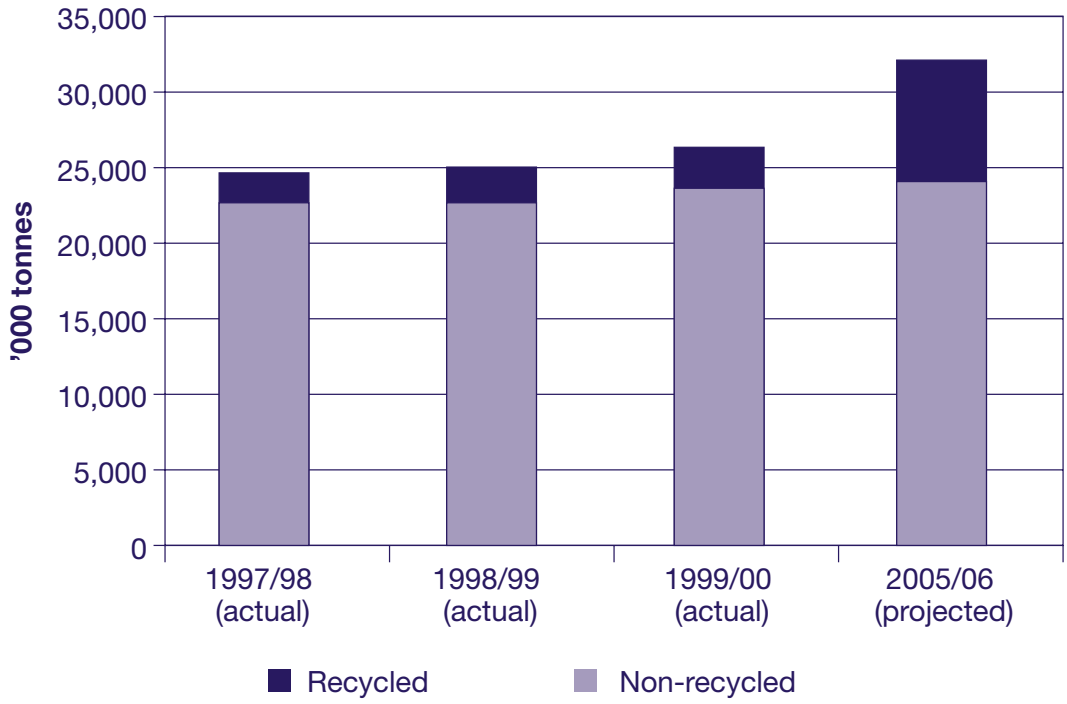
[15] OECD (2001a), op cit.

[16] A full list is included in Hession, M, "Working Paper: European Policy Review. Legislation Relevant to Energy and Resource Productivity", Imperial College (2001), available from the PIU.

[17] These pressures are felt most acutely in London and the south-east. For example, Greater London produced around 11 million tonnes of municipal, industrial and commercial waste in 1998/99 – but only 4 million tonnes was able to be disposed of within Greater London, with the remainder transported elsewhere. (Environment Agency, "State of the Environment Report for London, 2001" (2001), available at http://www.environment-agency.gov.uk/regions/thames/110327/?lang=_e&region=thames.)

[18] DETR, "Waste Strategy 2000 for England and Wales (Part 1 and 2)", CM 4693, (2000e), available at http://www.defra.gov.uk/environment/waste/strategy/cm4693/index.htm.

Figure 2: Recycled and Non-recycled Household Waste in England and Wales[19]



illustrated by the fact that achieving the interim target will require a trebling of the total volume of household waste recycling from the levels recycled in 1999/2000, based on current trends (Figure 2).

The built environment is an important driver for the sustainable use of resources, and the construction industry plays a significant role in the context of waste and climate change. The annual net change from rural to urban land use for the UK is in the region of 6,500 hectares; and 260 million tonnes of minerals are extracted annually for use as aggregates and raw material for construction products. Energy is consumed in the production of construction materials such as bricks, cement and metals and in their distribution. The energy produced from non-renewable sources consumed in building services accounts for about half of the UK's emissions of carbon dioxide. Over 90% of non-energy minerals extracted in Great Britain are used to supply the construction industry with materials. Yet every year some 70 million tonnes of construction and demolition materials and soil end up as waste. Some 13 million tonnes of that comprise material delivered to sites and thrown away unused.[20]

Among the other environmental challenges facing the UK, many are associated with transport. For example, the UK has had considerable success in reducing local air pollution, as set out in its Air Quality Strategy for England, Scotland, Wales and Northern Ireland.[21] But problems remain around busy roads, and it is not clear that technological improvements are set to keep pace with growth in transport demand. Subject to any long-term impacts from the terrorist attacks of autumn 2001, air transport could also be providing an increasingly important challenge, as the number of flights –

[19] Data taken from DETR and used in Hogg, D, "Waste in the Resource Productivity Framework", private report for PIU, Eunomia Research and Consulting (2001). Projection assumes that volume of total household waste continues to grow at 3.3% per annum, its average since 1996/97. Dark purple area in projection equal to 25% of total household waste.

[20] All figures quoted from DETR, "Building A Better Quality of Life – A Strategy for Sustainable Construction" (2000a).

[21] Details available from http://www.defra.gov.uk/environment/airquality/index.htm.

especially from regional airports – keeps on rising. Looking further ahead, the impacts of a changing climate could place increasing pressure on water resources in parts of the UK, especially the heavily populated south-east.

1.3 Responding to the challenge

If the economy grows at the anticipated trend rate over the next 50 years, the extent of the environmental challenge in these (and other) areas will be too great to be dealt with simply through "environmental" policies. What is needed instead is a continuing change in the way in which we carry out our activities in the UK, so that the economy grows in a way that is consistent with our social and environmental objectives. This can only be achieved if Government continues what it has already started by putting sustainable development at the forefront of policy-making.

The Government's Sustainable Development Strategy was launched in May 1999,[22] with the intention of delivering social progress, environmental protection, prudent resource use and high and stable levels of economic growth and employment. Underlying these high-level objectives are a number of key principles and approaches that are promoted through the strategy. And progress towards sustainable development is to be assessed in an annual report, now published by DEFRA.[23] An overview of sustainable development in the UK is provided in Annex C of this report. And Annex D analyses sustainable development in the English regions.

Putting the UK at the forefront of the global response

It is important to note that similar changes and strategies will be needed throughout the developed and developing world, so that the UK could benefit and lead the way through an early move to the necessary transition. Other countries are beginning to address the issue, and Danish Prime Minister Poul Nyrup Rasmussen wrote recently that:

"We should seriously consider including sustainability in our economic review process. For this purpose our countries should agree on a core set of indicators to measure progress in decoupling environmental and resource exploitation from economic growth… It is not enough to adjust policies and recommendations to present day realities. We have to anticipate change and be ready to respond adequately to the challenges of tomorrow."[24]

This report aims to help set the UK at the forefront of the global response.

1.4 Meeting the challenge

1.4.1 Barriers to overcome

If sustainable development is to be achieved, there will be a number of barriers to overcome.

Barriers to achieving sustainable development – and more especially to improving resource productivity – can be broadly divided into two categories. The first set of barriers are those that prevent the take-up of measures *already* beneficial on both economic and environmental grounds. The second set of barriers are those that prevent the take-up of measures that would be environmentally beneficial, and *should* be economically beneficial, but which for some reason are not.

[22] DETR (1999), op cit.
[23] DETR, "Achieving a better quality of life – Review of progress towards a sustainable development: Government Annual Report 2000" (2000) was the first of these annual reports.
[24] Rasmussen, Poul Nyrup (Prime Minister of Denmark), "Towards a Sustainable Future", OECD Observer (2001).

Analysis of energy productivity, now being carried forward in the review of energy policy, has highlighted what some of these barriers are. Within the first category, key barriers are as follows:

- **Understanding the full costs**
  When an assessment of costs and benefits shows that an activity would produce a net benefit, the general presumption from economics is that the activity should be carried out, and indeed will be carried out by rational economic agents (companies, households or other bodies). But experience in the real world – in waste recycling, energy efficiency and other areas – shows that this is often not the case. One reason for this is that the analysis of costs and benefits often fails to take account of the opportunity costs associated with an activity. These opportunity costs arise because – with finite resources and a finite number of hours in the day – undertaking one activity necessarily means that other activities cannot be undertaken. This means that economic agents prioritise even among beneficial activities. And activities to improve resource productivity are often low on the agenda.

- **Information deficiencies**
  Prioritisation will not even come into play if economic agents do not know about the cost-effective opportunities to improve resource productivity that are available to them. The example of energy efficiency suggests that this is often the case. High-energy-users will see energy as a key cost, and will hence focus attention on how to keep costs down, making sure that they know all of the options available to them. But relatively low-energy-users will often not know that they could save money by taking measures to improve energy efficiency. And similar circumstances will apply to resource productivity and resource use more generally. The problem is exacerbated by the fact that obtaining the relevant information can itself require expenditure of time and money under current market structures.

- **Limited access to capital**
  Economic analysis tends to assume perfect capital markets, so that if economic agents require an up-front injection of capital in order to undertake an investment that will prove cost-effective over its lifetime, they are able to obtain that capital. In practice, this is often not the case. And it is no coincidence that the worst performers in terms of resource productivity are often small businesses and less well-off households, whose access to capital is the most constrained.

- **Contractual problems**
  Problems relating to contractual relationships arise in a number of circumstances, each of which can act as a barrier to resource productivity. One example, which economists call a principal/agent problem, concerns the relationship between landlords and tenants. It is widely recognised that energy efficiency is often worst in tenanted households. And this can often be because tenants have no incentive to undertake energy efficiency improvements, while landlords are unaware of what could be undertaken. Even if they were aware, there would then be further issues to address in terms of the implications for the level of rent charged by the landlord. Similar issues arise for businesses that do not own the buildings from which they operate.

- **Skills shortfalls**
  Even if companies and households wanted to take up all cost-effective measures to improve resource productivity, this would not be feasible – at least in the short term – because there are not enough experts, individuals and organisations with the skills and knowledge to advise on and implement the measures. This is a legacy

of the lack of attention paid to resource productivity in the past, and could create a vicious circle that will take some time to close.[25] The skills shortfalls may help to explain why, for example, many of the new technologies to make electricity supply and usage less polluting and more efficient have been developed and exploited in higher-skilled countries such as Germany.

Other barriers skew the decision-making process

Each of these barriers will also act as a barrier to the take-up of measures that should be economically, as well as environmentally, beneficial. But there are two much more fundamental barriers to making progress towards sustainable development.

- **External costs**
  Companies and households almost always respond to the private costs and benefits that affect them. They cannot be expected to take decisions based on wider costs and benefits affecting society more generally. Thus it is no surprise that decision-makers fail to take up measures that will not prove cost-effective to them. The problem lies with a discrepancy between private costs/benefits and social costs/benefits. The latter reflect the full impact of activities on society as a whole, and will include, for example, environmental and social impacts. In contrast, the former reflect only the impact on the individual decision-maker.

- **Uncertainty**
  Even if current costs and benefits are adjusted to reflect social costs, companies and households may still hesitate in taking forward action to reduce resource use, enhance resource productivity and deliver both economic and environmental objectives. This is because many investments, and particularly the development of innovation, are subject to long time lags between the up-front costs and long-term benefits, or are subject to long lifetimes. If there is uncertainty about the future realisation of those benefits, then decision-makers will hesitate to make commitments, even if present circumstances suggest that they should go ahead.

Despite the barriers, many UK companies have made great strides in improving the productivity and efficiency with which they use resources, and in reducing the levels of waste and pollution for which they are responsible. The evidence suggests that attention has been concentrated on larger companies.[26] But the data shows a large potential for cost-effective waste reduction and energy efficiency improvement among the medium and small companies that make up most of the UK's business community.[27] The particular barriers faced by small businesses and approaches to deal with the problem are discussed in Annex E.

1.4.2 Turning trade-offs into synergies

The barriers identified are holding back action that could and should be taken to move towards the goals of sustainable development. But given the scale of the challenge, it would be misleading to suggest that sustainable development will be achieved simply by removing these barriers.

[25] A suitably skilled workforce will not develop until the resource productivity "industry" grows to the extent that a clear signal is sent to potential workers and training organisations. But it is not clear that the industry will grow to that extent until after a more skilled workforce is available.

[26] For example, research carried out by the Energy Saving Trust (EST) for DTI in 2001 (Energy Saving Trust, "Energy and Environmental Support to UK SMEs" (2001)) suggests that of the nine main organisations and networks providing advice on energy efficiency, only three deal with companies employing fewer than 25 people, and even these have their focus on larger companies.

[27] DTI define small companies as those with 49 or fewer employees, and medium-sized companies as those with 50–249 employees. The European Commission has also specified thresholds for company turnover and size of balance sheet. Further details of these and other definitions are to be found at http://www.dti.gov.uk/SME4/define.htm.

In the longer term, the problem facing the UK and the wider international community is that many of the environmental impacts we are trying to reduce are inherently bound up in our everyday economic activity. If we simply project a continuation of recent trends, over the next 50 years we will continue to consume more energy, create more waste and require more transportation. That is the clear message from the Government's own projections.[28] And those projections need to be set in the context of known and anticipated targets to reduce, for example, greenhouse gas emissions, waste-to-landfill and local air pollution.[29]

Under "business-as-usual" projections, we will increasingly be facing trade-offs, for example between economic and environmental objectives. Those trade-offs could impose significant costs on society, either through limits to economic growth, or through the effects of environmental damage. For example, the Inter-Governmental Panel on Climate Change (IPCC) estimates conservatively that climate change will cause "net economic losses in many developing countries for all magnitudes of warming studied" and that the world as a whole will undergo a range of impacts, with "increasing net losses […] for larger increases in temperature".[30] And the IPCC has also estimated that in the absence of emissions trading, costs of complying with the Kyoto Protocol – only the first step in dealing with climate change – will on average reduce GDP in 2010 to 0.2–2.0% less than it would have been, in those countries that have accepted greenhouse gas emission targets (reduced to 0.1–1.0% of GDP with emissions trading).[31] This is equivalent to a reduction in annual growth of up to a quarter of one per cent per year.

Changes will be needed

In order to avoid these trade-offs, and to create instead synergies between economic and environmental objectives, significant changes will be needed throughout the economy, compared with the ways in which we have carried out activity in the past. These will enable us to grow the economy without coming up against the limits associated with energy use, waste generation and transport. The next chapter shows that improvements in resource productivity could be one of the key elements.

[28] See, for example, DTI, "Energy Projections for the UK", Energy Paper 68 (2000) and DETR, "Transport 2010 – The 10 Year Plan" (2000d).
[29] Some of these targets are further discussed in Annex C.
[30] IPCC, "Climate Change 2001: Impacts, Adaptation and Vulnerability – IPCC Working Group 2 Summary for Policy-Makers" (2001).
[31] IPCC, "Climate Change 2001: Mitigation – IPCC Working Group 3 Summary for Policy-Makers" (2001a).

2. IMPROVING RESOURCE PRODUCTIVITY AND DELIVERING SUSTAINABLE DEVELOPMENT

Summary

- Resource productivity is a measure of the efficiency with which the economy makes use of natural resources.
- The Government's main concerns about natural resource use are in relation to impacts on the environment. For this reason, it is helpful to take a wide definition of natural resources, including within them the resource provided by pollution "sinks".
- Improvements in resource productivity can help to deliver sustainable development. They will do this through a number of mechanisms – perhaps most notably by easing the constraints imposed by environmental limits on economic growth.
- Improving resource productivity can also make sense for the private sector – not only by cutting costs and improving overall productivity, but also by improving reputation and other more nebulous impacts.
- Innovation will be a key to achieving resource productivity improvements throughout the economy. Technological innovation will need to be accompanied by institutional and social innovation.
- By providing another way of looking at the sustainable development challenge, resource productivity can help to inform policy-making. The first example will be the Performance and Innovation Unit (PIU) review of energy policy.

2.1 What is resource productivity?

Resource productivity measures the efficiency of the economy in generating added value from the use of natural resources

Delivering the goal of sustainable development will require progress to be made against economic, environmental and social objectives. This is what the UK's Sustainable Development Strategy seeks to achieve, and one of the key themes in the strategy is the role of resource productivity. The strategy itself states that resource productivity is "a key to change".[32] And the Government's "Annual Report 2000"[33] on progress towards sustainable development defines resource productivity as *"getting the most out of finite resources, maximising the use of renewable resources and minimising waste".*

Resource productivity can be defined simply as output per unit of natural resource input. This is directly analogous to the GDP per hour worked or GDP per worker definitions of labour productivity. The most common example of this simple measure is energy productivity, or more commonly energy efficiency, which measures the ratio of output or value added per unit of energy used.

Chapter 3 looks in some detail at the practical measurement of resource productivity, using a variety of measures from complex metrics to simple proxies. But one key issue to address is the definition of natural resources. The usual definition would incorporate renewable and non-renewable natural inputs. Non-renewable or stock resources include minerals, land and fossil fuels used as energy resources. Renewable resources include water and biological resources. It is the productivity with which we use these resources that will tend to be of more concern to private decision-makers – the basic question being, "How can I make more with less?".

But from the perspective of policy-makers, what is perhaps of more concern is the waste and pollution output associated with resource unproductive processes. Resource inputs are only partial proxies for these output effects.[34] One way of capturing the issues would be to define a measure of environmental productivity as output or value added per unit of waste or pollution output. One example of this would be GDP per tonne of carbon-equivalent greenhouse gas emissions (often termed carbon intensity).

We can capture scarcity and environmental damage within resource productivity

But rather than have two separate measures, this report prefers to retain a single measure of resource productivity and to extend the definition of natural resources to include the resource provided by pollution sinks. This resource is provided by the capacity of the environment to absorb waste and pollution of all forms. It includes the role of the atmosphere and of forests in absorbing greenhouse gases, the role of land in absorbing waste, and the role of water in absorbing water pollution, in addition to many other sinks. Under this definition, resource productivity effectively incorporates the concept of environmental productivity.[35]

[32] DETR (1999), op cit.
[33] DETR (2000), op cit.
[34] For example, one of the main concerns surrounding the burning of fossil fuels is the release of greenhouse gases which cause global warming. One way to reduce these harmful waste outputs would be to use less of the inputs. But another way would be to capture and store the greenhouse gases released (known as carbon sequestration) – requiring no change in inputs.
[35] Although this approach is the more helpful in conceptual terms, Chapter 3 will note that practical measurement is likely to remain focused on the more narrow definition.

2.2 Why does it matter?

Chapter 1 of this report identified the scale of the challenge we face in delivering the goal of sustainable development. And the DTI's sustainable development strategy talks about the need for "step change improvements in the use of energy and materials".

Synergies rather than trade-offs

However, because improvements in resource productivity are a means towards the end of sustainable development, rather than the end itself, it is important to understand how resource productivity improvements will help. Annex F assesses in some detail the literature on links between resource use, environmental damage and economic growth. What the literature shows is that there are a number of significant interactions between economic and environmental objectives – and many of these are mediated by changes in resource productivity.

At the centre of sustainable development is the need to move away from approaches that see environmental objectives purely as constraints on economic performance. At the extreme, environmental objectives can indeed impose constraints. The Government's Sustainable Development Strategy recognises that certain environmental issues involve limits that should not be breached (see Annex C). Examples given include major climate change, overuse of freshwater resources, or collapse of globally significant fish stocks. But the danger is that by focusing on environmental objectives as constraints on economic objectives, attention is directed primarily towards trade-offs between the two. What the literature shows is that when improvements are made in resource productivity, there can be considerable synergies. Finding and exploiting these will play a key role in delivering the goal of sustainable development.

Areas where resource productivity improvements can help include the following:

- Where there are genuine limits associated with environmental problems, in terms of the degree of environmental degradation that can be endured, or where there are limits to the availability of non-renewable resources, improvements in resource productivity will make those limits less binding.
- Many types of economic activity are resource-input-intensive, or have a major impact on environmental resources. If individuals and companies faced the costs associated with those impacts,[36] improvements in resource productivity would help to cut costs as well as cutting down on waste and pollution.
- At its heart, sustainable development is all about improving the quality of people's lives, both now and in the future. Improving resource productivity – and hence improving the environment – will help to improve quality of life in a way that will not necessarily be picked up by the national accounts.
- The relationship between resource productivity and the productivity of labour and of capital is unclear (Chapter 3 discusses this in more detail). But what we do know is that people and machines work less effectively when they are suffering from the effects of environmental damage, such as local air pollution or release of corrosive substances. Resource productivity improvements will help to reduce these effects.

[36] This reflects the "polluter pays principle", which is one of the guiding principles of the Sustainable Development Strategy (Annex C), and which is also reflected in the Government's Statement of Intent on Environmental Taxation (Chapter 4).

- Resource productivity improvements may also be to some extent self-reinforcing. The productivity of natural resources may be adversely affected by environmental damage (for example, global warming causes rising sea levels and saline intrusion – increasing saltiness of local air, land and water – which can damage crops).[37] Resource productivity improvements will reduce this damage.

2.3 Resource productivity and the private sector

The previous section focused on some of the benefits of resource productivity improvements that will be of interest to policy-makers. But many businesses and households are already aware that improving resource productivity can make sense for them too. Improving energy efficiency and cutting down on waste provide the two best examples.

However, the opportunities for making money from improving resource productivity are not limited to these areas alone. Forward-thinking businesses and households are identifying other areas where improvements can be made, cutting costs and improving the environment at the same time.

Because of the barriers identified in Chapter 1, there is considerable untapped potential for businesses and households alike to undertake energy efficient investment that will pay for itself over relatively short timescales through savings in energy costs. What this means is that if effective barrier-busting policies can be identified and implemented, that potential could be tapped, improving energy productivity, reducing the use of fossil fuels, saving money and alleviating fuel poverty.

Box 1: Two approaches

The Energy Saving Trust works with a wide range of partners to deliver energy efficiency to domestic consumers through a range of grant-funded programmes. These include: provision of information to domestic consumers; promoting energy efficiency partnerships within the industry; promoting domestic energy services; provision of subsidies for energy efficiency measures such as lighting and insulation; and grant provision to local authorities to help them set up energy efficiency initiatives. The organisation's main focus is promoting energy efficiency measures that will save people money and will be environmentally beneficial.

Envirowise (formerly the Environmental Technology Best Practice Programme) offers free advice and resources to UK companies to persuade them that adopting waste minimisation techniques can deliver considerable business savings – about £1,000 per employee in manufacturing companies. Envirowise provides on-site visits; a helpline; seminars and workshops; and good practice guidance. They have over 300 publications and over 1,500 small companies have taken up the offer of free on-site visits; and 15,000 company delegates have attended seminars and workshops. Annual cost savings to industry now exceed £150 million and environmental benefits include the reduction of over 270,000 tonnes of raw material usage per year.[38]

[37] Annex E notes that some effects will work in the opposite direction, and it is not clear that the net effect will be negative in all circumstances.

[38] More information on the EST can be found at its website at http://www.est.co.uk; more information on Envirowise can be found at its website at http://www.envirowise.gov.uk.

Box 2: Barrier-busting in energy efficiency

The PIU's initial work on energy efficiency (now being developed within the review of energy policy) suggests that the best policy options for energy efficiency are those that set a framework within which industry, individuals and organisations have both the incentive and the capacity to implement energy efficiency measures. This would require Government to do two things:

- identify the organisations best placed to deliver in each energy-using sector and provide them with the right framework for doing so; and
- assist in capacity building, where necessary.

Working with other organisations and stakeholders, Government has already made a start on this agenda:

- For low-income households, the Government and devolved administrations have taken direct responsibility through public expenditure funded programmes.
- For domestic energy users the Energy Efficiency Commitment gives incentives to licensed gas and electricity suppliers.
- In new buildings, Building Regulations give energy efficiency responsibility to the builders.
- For appliances, EU standards and negotiated agreements increasingly provide a framework for improvements in energy efficiency.
- The Climate Change Negotiated Agreements give a strong fiscal incentive to the industrial sectors involved.
- In the public sector, Government departments have energy efficiency targets.
- For cars, there are EU agreements with vehicle manufacturers.

The review of energy policy will seek to build on this approach in making recommendations and this report deals with some of the issues in greater detail in section 2.5.3.

Recycling provides another example where barriers are getting in the way of progress (Annex G). At present, there are limited incentives for companies to recycle their own waste, and limited incentives for them to use their own recyclate or purchase recycled products from other companies. It is because of this that the market for recycled goods has – with one or two exceptions (notably paper) – been so slow to develop in the UK. Government is now taking action to overcome barriers and change the incentives, through a range of instruments from the landfill tax to the work of WRAP (Waste and Resources Action Programme).[39] When companies begin to respond to these signals, they will generally discover that recycled products can provide inexpensive and high-quality alternatives to primary resources.[40] At the same time, the recycling industry itself will take off, offering new business opportunities, and jobs for the low-skilled (in collecting waste for recycling) and high-skilled (in waste reprocessing) alike.

[39] WRAP (Waste and Resources Action Programme), "The WRAP Business Plan – creating markets for recycled resources" (2001), available at http://www.wrap.org.uk.
[40] WRAP (2001), op cit.

Another area where progress is needed is in the procurement of new buildings. A step change in procurement policy for new buildings is needed to recognise that best value for long-term occupancy may not be secured by seeking the lowest construction costs. The National Audit Office (NAO) pointed up the fact that over the lifetime of a building, if construction costs = 1, then maintenance costs = 5 and running costs = 200. The focus in procurement should be on reducing running costs, yet most effort goes into the "1 + 5" not the "200". Design improvements that focus on achieving efficiency in running costs can have huge benefits.

Improving resource productivity can also increase focus on the triple bottom line

It is also worth noting that business success is not only measured by the financial profit and loss account. Attention is increasingly being drawn to the triple bottom line of financial, social and environmental performance, in which all three aspects are important for long-term value and success. Improving resource productivity should help to improve performance against the first two of these.

The business benefits of Corporate Social Responsibility (CSR) are increasingly understood and accepted by multinational enterprises. Historically, reputational risk factors were identified as the strongest influence for companies choosing to follow CSR policies. Several high-profile cases of companies whose brand image was tarnished by activities in developing countries showed graphically the correlation between reputation and the profit margin.

However, current work on CSR has a greater emphasis on the fact that companies which behave as corporate citizens can also benefit. This benefit manifests itself beyond simple reputational issues, but at many different levels throughout the business – enhanced risk management, staff retention and effectiveness, capacity for organisational innovation, etc. At the macro level, a study by the Ethical Investment Research Service (EIRIS)[41] found that the long-term performance of 15 unit trusts had a lower total risk than non-ethically invested funds with overall performance very similar to market indices. Further evidence of the increasing value being attached to CSR is provided by the inception of funds under the Dow Jones Sustainability Index and FTSE4Good banners (Annex H).

In addition to these private sector initiatives, the independent Company Law Review (CLR) has considered issues such as wider reporting on social and environmental performance. The final recommendations of the CLR proposed that all very large private and large public companies should produce a statutory "Operating and Financial Review" (OFR) – a report which would give a wider, more narrative view of the performance and position of the company. Under the CLR recommendations, the OFR includes mandatory disclosure of certain risks, such as environmental costs and liabilities. It also includes disclosure on areas such as the company's key relationships with stakeholders and on the company's policies and performance on corporate responsibility and environmental issues, where the directors judge them material.

It is hoped that whatever changes may be made to company law arising from the recommendations of the CLR, along with the various best practice initiatives already in place,[42] will lead to a change in businesses' responses to CSR issues. However, this area is still in an early stage of development.

[41] EIRIS, "Does ethical investment pay?" (1999).
[42] See, for example, http://www.bitc.org.uk.

This may account for the evidence that suggests that, at this point, the Prime Minister's call for "all of the top 350 [quoted] companies [in the UK] to be publishing environmental reports by the end of 2001" does not look to have been taken up.[43]

Recommendations to encourage the triple bottom line

In view of the limited take-up of "triple bottom line" reporting, there are arguments in favour of exploring ways in which this might be made compulsory in the longer term. One option would be for reporting to be made compulsory, but for the format and standard to be left up to business. Another option would be to make reporting compulsory according to the standards of an existing initiative, such as the Global Reporting Initiative (GRI).[44]

However, given the process started by the CLR, and the fact that the "triple bottom line" is still in its infancy, this would seem to be premature. In the case of environmental reporting, however, the situation is more advanced. It is more widely adopted than wider sustainability or triple bottom line reporting, and there is a marked difference in take-up between companies, both within and between sectors. **It is recommended that the Government's environmental reporting guidelines,[45] published by DEFRA and DTI, should be kept under review.** At the same time **it is recommended that DEFRA and DTI, in consultation with HM Treasury and DFID, should consider the extent to which voluntary measures and the proposals from the Company Law Review will lead to a level of reporting which meets its objectives.**

On CSR generally, the role of Government should be to highlight best practice and work with partners to provide advice and guidance on socially and environmentally responsible business activities. On dissemination, one initiative to be welcomed is the Business in the Community's Business Impact Task Force, which published its final report in November 2000.[46] This provides advice and signposts to further sources of advice on a wide variety of CSR-related issues including the environment. The Government Minister for Corporate Social Responsibility welcomed this report when it was launched and DTI helped support the Task Force.

2.4 The importance of innovation

The level of improvements required in resource productivity will not be easily achieved. There are of course some relatively easy gains available if barriers are removed. But looking further ahead, the challenge will become much greater. Innovation – in products, processes, institutions and society – will be crucial to achieving the necessary scale of resource productivity improvements. (The role of innovation is explored in some detail in Annex I to this report.)

In itself, innovation will not necessarily help resource productivity. Innovation – the "natural" market-driven changes to technology and practices – is not necessarily beneficial to resource productivity. It may be resource productive, or resource neutral, or indeed have negative impacts on resource use. In fact, the empirical evidence across countries and sectors suggests that technical progress has steadily improved resource productivity over time, but in most cases at a rate insufficient to keep pace with expansion in consumption.

[43] "Companies reject disclosure pleas", Financial Times (25 June 2001).
[44] Details available at http://www.globalreporting.org.
[45] Details available at http://www.defra.gov.uk/environment/envrp/index.htm.
[46] Details available at http://www.business-impact.org.uk.

Box 3: Electricity market liberalisation and innovation in a carbon-constrained world

Annex J explores in some detail the impact of electricity market liberalisation on innovation in the context of our policy goals to reduce greenhouse gas emissions. The main conclusion is that liberalised markets respond to commercial pressures – and without clear price and other signals, the direction of innovation in the liberalised market will not point towards a more resource productive future.

Of course, this is not to say that liberalisation has been bad for innovation. Indeed, liberalisation has itself been a good example of institutional innovation. And commercial pressures in the liberalised market mean that innovation is now much more focused and subject to much tighter controls. In addition, different companies are concentrating on their own areas of competitive advantage. The role for Government is to ensure that innovation is targeted in the right direction and at the right stages of the innovation process. These issues will be considered in more detail in the PIU review of energy policy, and in the separate DTI review of energy-related research and development.

The challenge for policy-makers is to ensure that resource productive innovation has adequate incentives and is supported. Such a policy will mean that innovation is explicitly focused upon resource use and the environment, and progress in these areas accelerates.

Environmental and innovation policy

Environmental policy is concerned with ameliorating environmental damage – for example, internalising external costs through a tax, regulation or market-based mechanism. These standard instruments of environmental policy have delivered environmental innovations in the past, and are undoubtedly essential to continuing to do so. The question is whether relying solely upon such instruments is the optimal policy for delivering resource productivity, environmental improvement and a sustainable future.

It is widely recognised that internalisation of external costs is an important element of policy to deliver sustainable development. But it is also self-evident that there are other barriers that will limit the effectiveness of internalisation policies. In addition, the Government's Statement of Intent on environmental taxation recognises that there are times when internalisation is not good policy, for example if it "fails the tests of good taxation".[47] And sending the right long-term signals for innovation may be difficult through internalisation only. What this means is that in practice, internalisation of external costs will often not deliver the desired outcomes in isolation.

There is therefore a case for targeting innovation directly. Policies effectively targeted to encourage creation of options are a robust response to uncertainty, and help reduce time-lags and trade-offs. They can help deliver long-term benefits by smoothing the transition to new environmental standards without the kind of short-term disruption that would result from forcing through abrupt changes.

Encouraging investment in innovation is already at the heart of UK productivity strategy. All innovation brings benefits that go beyond direct competitive advantages for

[47] HM Treasury, "Tax Measures to Help the Environment", News Release, 2 July 1997 (1997).

the innovator – the so-called positive externalities of innovation.[48] This is the justification for policies to ensure that innovators extract adequate rents – for example, through intellectual property rights (IPRs) and patents – and for other policies to support innovation more directly, into which the Government has recently injected new funding and effort.[49]

Innovation policy can be targeted at resource productivity improvements

However, support for innovation is viewed primarily as an issue for labour productivity and competitiveness. It has also tended to focus upon public sector research and development, with less emphasis on bridging the so-called valleys of death between research and commercialisation, though this is now changing.[50] But resource productivity innovations bring additional external benefits: the same public goods – such as clean air – that are subject to the externalities that environmental policy seeks to address.

The role of innovation in delivering resource productivity improvements is already reflected in some UK policies. Environmental technologies have benefited from research council and departmental r&d programmes, and through incentive schemes such as the Green Fuels Challenge and the Non-Fossil Fuel Obligation (NFFO). Despite this, historically, the extent to which environmental policy and innovation policy have been joined up to provide consistent support (and avoid the valleys of death) has been limited. The final report of a series of workshops examining support for resource productive innovation in the UK[51] concluded that:

"Innovation policies have placed little priority on the environment while environmental policies have focused on near term, near commercial solutions, and have neglected the development of technologies and practices of considerable economic and environmental promise in the longer term."

Addressing the gap between environmental and innovation policies requires careful attention to the nature and drivers of the innovation process itself. This is explored more fully in Annex I, but some of the key issues and their implications for policy are highlighted here.

Good practice principles

Innovation is a complex and non-homogeneous process. Significant differences exist between industries as to the drivers, scope and scale, and nature of innovation. These reflect the nature of the industry, its structure and the number/market power of firms – all of which interact in complex ways to shape how innovative the industry might be, and who will drive innovation (in-house or university, incumbents or new entrants). The literature on this has spawned a number of terms – disruptive, radical, incremental – which are discussed in Annex I. All are important. Innovation is sometimes referred to as a chain, starting with r&d and ending

[48] Economists identify two positive externalities associated with r&d. The first is called the "consumer-surplus effect", and arises because innovators cannot procure all of the benefit from innovation in competitive markets – some of it will be passed on to the consumers of innovation (i.e. those who license the innovation in order to produce goods). The second is called the "inter-temporal spillover effect" – even if a patent is issued for a new innovation, the knowledge associated with that innovation can generally be used by other innovators in the future. Finally, there is also a negative externality called the "business-stealing effect", arising from the introduction of new innovations that render existing goods obsolete, causing harm to the owners of those goods.

[49] See DTI, "Excellence and Opportunity, a science and innovation policy for the 21st century" (2000a).

[50] DTI (2000a), for example, places particular emphasis on commercialisation based upon UK scientific strengths, for example through technology "clusters" and "spin outs" from universities.

[51] These workshops, sponsored by Economic and Social Research Council, brought together senior academics, policy-makers from all relevant departments and senior industry representatives, and were built around a programme of research and analysis, see Anderson, D, Clark, C, Foxon, T, Gross, R and Jacobs, M, "Innovation and the Environment: Challenges and Policy Options for the UK", Imperial College (2001).

with the commercialisation of a new product. However, innovation is more accurately viewed as a complex network or system, with feedbacks between different actors at different stages of the process. And the nature of the network will differ between industries.

This presents a complex picture for the policy-maker. It might be tempting to retreat into the old paradigm whereby Government focuses solely upon support for fundamental r&d, leaving the rest to the market. Fundamental r&d is important, and there is a good case for building resource productivity criteria into the heart of research funding criteria. However, relying solely upon the r&d budget would be misconceived. There are two reasons why. First, the obstacle to innovation may not be a lack of research, or a need for new ideas, it may be the capacity and willingness of firms to develop and commercialise new approaches. Second, the incentives to pursue more resource productive approaches may be limited – secondary to more directly market-related priorities. Internalisation of externalities can change this, but it is also possible to target innovation more directly.

This suggests that the policy-maker may use a basket of instruments to create incentives and support resource productive innovation. Specific recommendations are provided in Chapter 4; however, the fundamentals of intervention are as follows (see Annex I for further details):

- Ensure that support for basic r&d targets resource productivity, and that this research is adequately resourced. Relevant areas will include material science, advanced systems design and biotechnology.
- Assist firms and universities in bridging the gap between research and commercial development. Some benefits could arise by including "resource productivity" or "sustainable development" as a suitable heading for designing LINK programmes.[52]
- Strengthen public-private venture fund partnerships focused on delivery of resource productive innovation and investment.[53]
- Create niche markets that enable new products and practices, not yet competitive with established alternatives, to benefit from "learning by doing" and gain economies of scale. One way of establishing niche markets is through so-called "greening procurement" (see section 4.2.4).
- Address barriers within industries, including financial barriers (access to capital for smaller companies with innovative products) and structural (where new entrants are excluded and where incumbents are likely to be unwilling to innovate).
- There are also industries where the incumbents themselves are more likely to be the main source of innovation, and where innovations are more likely to be incremental (for example, in highly complex and capital intensive process industries). In such cases incentives for resource productive innovation are all important.
- Incentives for innovation can involve variants on the standard instruments – but a focus on driving innovation suggests two key features:

[52] The LINK scheme is the Government's principal mechanism for promoting partnership between industry and the research base in pre-competitive research. Existing categories fall into five main programmes: Electronics/Communications/IT; Food/Agriculture; Biosciences/Medical; Materials/Chemicals; Energy/Engineering. Further information is available at http://www.dti.gov.uk/ost/link/.

[53] The "Myners Report" (Myners, P, "Myners Review of Institutional Investment: Final Report" (2001)) recommended this type of Government action to fill gaps in regional and technology venture capital markets. Government announced in "Budget 2001" (HM Treasury, "Budget 2001" (2001)) that it would take forward all of the recommendations in the report.

- Maximum flexibility for companies to find innovative solutions themselves – outcome-based targets or standards backed by regulation or fiscal incentives.
- Sufficient time for innovation to come on stream – which suggests clear and long-term commitments with staged implementation of targets or standards.

- New incentives may also be created, such as back-loading support for innovation (as opposed to front-loading through the r&d programme) with a financial prize for resource productive products, or perhaps a secure niche market.

None of these interventions is unique to resource productivity. And all need to be seen in the context of wider European and international developments. In a sense what is needed is for UK innovation policy to catch up and do for resource productivity technologies what it is already doing for genomics, information and communication technologies and the rest. If we can do this effectively we will get green growth – a synergy between conventional competitiveness/productivity policy and environmental objectives.

2.5 Resource productivity as a conceptual tool

The focus of this report is on the resource productivity improvements that will help to deliver our goal of sustainable development. In setting policy to improve resource productivity and deliver this goal, it may also be helpful to use resource productivity as a conceptual tool within our existing decision-making frameworks. This section sets out some examples.

2.5.1 International competitiveness

Delivery of sustainable development is a global challenge. Many of the environmental pressures faced by the UK already have an international context. It may be direct, through the UK's involvement in international (such as the Kyoto Protocol on Climate Change[54]) or European (such as the Landfill Directive[55]) agreements or legislation. Or it may be indirect, because other countries are facing similar challenges to the UK, within their own borders.

At the same time, the UK economy operates within a competitive environment. This puts pressure on the UK to improve its productivity and to develop its economy, in order to raise the living standards of its inhabitants. In addition, the UK is subject to international (for example, the rules of the World Trade Organization) and European (for example, the rules of the Single Market) agreements and rules.

Environmental and economic objectives may conflict

The UK's economic and environmental objectives may come into conflict with one another, particularly in the context of international competitiveness. There are a number of reasons why it may be inappropriate for the UK to take early action on environmental issues:

- Where our competitors are not yet facing up to the wider costs of their activities, and are hence benefiting from artificially low prices, taking action to increase costs in the UK will damage competitiveness in the affected industries, and may simply drive polluting activities overseas – irrespective of the fact that increasing costs may be the theoretically correct response to environmental damage.

[54] UNFCCC (1997), op cit.
[55] Commission of the European Union, "Directive 1999/31/EC of 26 April 1999 on the landfill of waste" (1999), available at http://www.europa.eu.int/eur-lex/en/lif/dat/1999/en_399L0031.html.

Box 4: The Danish wind turbine industry

Denmark's economy has benefited greatly from the country's commitment to wind energy. Danish involvement with wind energy dates back many decades. A pioneering r&d programme in the 1950s is credited with developing the prototype for all modern wind machines. However, the current era has its origins in the 1970s' oil shocks and policy support dates from the 1980s.

Core elements of the support have included both "demand pull" and "supply push". On the demand side, key elements have included:

- direct subsidy, initially through installation grants (abolished in 1989), and more recently through reimbursement of the CO_2 levy;
- fixed price support, initially through a guaranteed high price, now being phased out in favour of tradable certificates;
- tax incentives, particularly for local ownership; and
- favourable planning regime.

On the supply side, key elements have included r&d programmes, a national test station facility and a process of standardisation and approval of turbine design. From the outset, the focus was on local, private ownership of turbines and the progressive development of wind energy by (initially) small, private enterprises. Technologies also started small and developed gradually, through a process of "learning by doing".

Denmark now secures 15% of its electricity from wind, with plans for continued expansion. It has also facilitated the growth of a new industry. The Danish wind turbine industry now accounts for more than 50% of sales in a world market growing at 25% per year; enjoys annual turnover of around 2 billion euros; and directly employs around 4,000 people, with around 10,000 more employed in component manufacture. The industry is now about three times the size of the shipbuilding industry, and employs more people than the electricity supply industry.

- Action at international or European level is appropriate where the adverse environmental impacts of activity in one country are felt in other countries. Climate change is the classic example of this – greenhouse gas emissions from all countries combine together to produce a global problem, so that there is little or no direct correlation between the gases emitted and the damage suffered in any one country.
- There are valid concerns that those countries moving early can simply make the mistakes from which the later movers will learn.

Resource productivity improvements can create opportunities for the UK

If environmental issues can be tackled through improvements in resource productivity, the international context might be seen to provide much more of an opportunity and less of a threat. Trade-offs still need to be assessed and avoided. But there are also synergies to be exploited:

- By overcoming barriers to greater resource productivity, it should be possible to help UK business cut costs and potentially improve its competitiveness, particularly where resource costs are a significant proportion of total costs.
- Looking to the longer term, if we can be confident that other countries will have to face up to similar challenges, there is the potential for UK business to enjoy a longer-term and less disruptive transition to the more resource productive structure that our competitors may have to achieve more abruptly.
- There may even be potential for the UK to influence what happens internationally, and to export the technologies, institutions and expertise associated with sustainable development to other countries – helping them to develop in a sustainable way, while potentially boosting UK business.

Understanding the issues in an international context

Although in some cases it will be appropriate for the UK to move in tandem with its competitors in taking action to tackle environmental problems, in other cases, there will be opportunities and benefits from moving early in terms of our ability to export. It will be important for the UK to identify where there are these opportunities, and where there could be threats.

It is recommended that as a first step, DEFRA should work with DTI, FCO, DFID, HM Treasury and ONS to evaluate the international aspects of UK environmental improvement to date. Is there any evidence to suggest that the UK has been able to export experience or technology linked to environmental improvement? Or is there evidence to suggest that some of the improvements in the UK have simply resulted from the export of environmental pollution and risks of unsustainable development to other countries, through structural shifts that have seen more polluting processes move elsewhere? Advice on the first question will be available from the Joint Environmental Markets Unit (JEMU);[56] analysis of the second question can draw on the existing work programme of the Inter-Departmental Ad Hoc Group, established by the PIU project "Rights of Exchange".[57] The analysis should be undertaken in such a way as to inform future policy-design, so that the opportunities are maximised and the threats minimised. It should build on existing data and ongoing work being carried out by the ONS in linking the environmental accounts of different countries. And it should draw on the good and bad experiences of other countries in developing their environmental policies.

2.5.2 National policy-making to improve the environment

Resource productivity perspectives can help identify where Government needs to act

National policy-making to improve the environment is already focused on overcoming the market failures and barriers that are holding back environmental improvement. The concept of resource productivity can assist in this approach by helping to identify barriers

[56] The JEMU website is at http://www.dti.gov.uk/jemu. JEMU's responsibility is to promote and support the UK environmental industry.
[57] PIU, "Rights of Exchange: Social, Health, Environmental and Trade Objectives on the Global Stage", (2000), available at http://www.cabinet-office.gov.uk/innovation/reports/reports.shtml.

outside the remit of what would typically be called environmental policy.

HM Treasury has successfully identified and tackled barriers to improved labour productivity. The same approach can be adopted for resource productivity. Many similar themes will apply – including the presence of externalities and public goods, exercise of market power, informational problems and regulatory/fiscal barriers. A similar assessment of these barriers for resource productivity could uncover problems that have hitherto been missed, and could help to target policy action more effectively, improving the economy and the environment.

The merits of this approach are the same as the merits of the approach already applied to labour productivity. So the issues surrounding dynamic impacts and changes, macroeconomic/microeconomic interactions, innovation/investment and the functioning of markets – all addressed in the Government's Productivity Strategy – would be similarly addressed in the context of resource productivity and environmental policy-making.

This way of thinking has not previously been applied in a systematic way to environmental policy-making, and there is a lot to learn. **It is recommended that DEFRA, DTI and HM Treasury economists set up an inter-departmental group, drawing in economists from other Government departments and from outside Whitehall, to take this work forward.** The purpose of the group would be to identify systemic barriers to resource productivity, and suggest how they might be overcome, drawing on the lessons from the Government's successful approach to labour productivity. In doing so, the group would be able to identify how the concept of resource productivity, and associated analysis, might be able to add to existing tools.

2.5.3 The review of energy policy

The objectives of energy policy relate directly to the economic, environmental and social goals of sustainable development

The PIU is currently undertaking a review of energy policy, due to report to the Prime Minister by the end of 2001. The main aim of the project will be to set out the objectives of energy policy and to develop a strategy that ensures current policies are consistent with longer-term goals. Those goals will be firmly embedded in the three pillars of sustainable development, each of which has a particular focus within the context of energy policy:

- **Economic:** generally expressed as the desire for economic efficiency or cost-minimisation, and the use of resources where they best meet needs. It is generally delivered by market forces, but intervention (such as through market instruments or regulation) is needed where there is market failure. And if the market failure relates to social or environmental objectives, intervention that reduces efficiency may be justified – an example of trade-offs in action.
- **Environmental:** the reduction, or potentially the elimination, of environmental impacts. The most obvious concern is greenhouse gas emissions. But we also need to consider nuclear waste, local air quality, solid waste, and water and noise/visual impact.
- **Social:** most notably the need to ensure that the poorer members of society can access energy services at an affordable cost.

Defining the sustainable development context for energy policy is a key area of ongoing work for the review. Once the objectives are defined, the review will then

draw on the framework set out in this report. In particular, the challenge will be:

- to identify when the overarching objectives (and associated sub-objectives) are in harmony, and when they are in conflict. In the former case, there will be synergies that can be exploited through carefully designed policy. In the latter case, policy will need to address trade-offs; and
- to consider, especially in circumstances where trade-offs are likely, the relative importance of different objectives, and how this balance will change over time.

In carrying out each of these stages, measurement issues will arise which are similar to those addressed in section 3.3 of this report. Some quantified and even monetised estimates of social and environmental impacts do occur, but these are by no means universal and are often subject to considerable uncertainty. This suggests that standard economic tools such as cost-benefit analysis may be limited in their application. Even cost-effectiveness analysis, which expresses all other costs and benefits relative to the objective (for example, per tonne of greenhouse gas emission), will be limited where there is more than one non-monetised objective.

The standard tools will certainly have a role to play, but the decision-making framework employed will need to operate across a range of criteria, some of which will be measured on a largely qualitative basis, or through use of proxies. Two key themes will be security of fuel sources and of the energy system – which will be key in delivering against economic and social objectives – and decision-making in the context of risk and uncertainty.

Energy innovation and investment cycles are long

Another key aspect of the review methodology will be its focus on the long term as well as on the short term. This report has highlighted the dangers of a short-term perspective, particularly in the context of the importance of innovation in helping to deliver economic, social and environmental objectives into the future. The innovation cycle can often occur over a very long time period, making it essential that long-term issues are incorporated into policy frameworks and incentive structures. This is most important where large-scale infrastructure and big institutions are involved, as is the case with energy.

The review is looking at a range of energy systems – institutions, technologies and infrastructures – that could deliver the sustainable development objectives in a number of alternative future scenarios. This will help to identify desirable outcomes that are robust against a wide range of uncertainty, so that energy policy can establish incentive structures that will enable energy markets to deliver these outcomes. Alternative approaches will be compared against the full range of economic, environmental and social objectives, in order to draw conclusions about the best way of moving forward.

Improving energy efficiency

One of the major themes of the review will be energy efficiency, and the role it can play on the demand side of the energy market. Box 2 in section 2.3 highlights some of the "barrier-busting" measures that are being considered. Energy efficiency can be thought of as a particular example of resource productivity. Improvements in the ratio of economic output to energy use (a measure of energy productivity) can make a significant contribution to environmental objectives,

Box 5: Renewable energy and resource productivity

It is generally acknowledged that although the contribution made by renewables to UK electricity needs is at present relatively small, their potential is very large indeed. Renewable energy can play a big part in improving resource productivity and contributing to sustainable development, because it enables energy to be used without greenhouse gases being released.

The PIU is exploring various renewable technologies as part of the review of energy policy – these include onshore and offshore wind, building-integrated photovoltaics (PV), wave energy and biomass. Preliminary analysis shows that the technical potential for these sources could exceed total UK electricity demand of some 350 TWh/year. UK policy sets a target of 10% of electricity from renewables by 2010. Modelling work by the PIU suggests a target of 20% by 2020 is feasible, and preliminary analysis of the implications of a more ambitious target of 30% is under way.

Cost trends indicate significant and sustained cost reductions secured by renewables, such as wind and PV, which have a track record of market development. The cost of PV is one-fiftieth of what it was in the mid-1970s. The cost of onshore wind energy is one-eighth of what it was at the beginning of the 1980s. Cost reductions may similarly be achieved in time for other forms of renewable energy. The PIU's proposition is that the cheapest options for exploiting renewable energy sources will become broadly cost competitive with "conventional alternatives" within 20 years.

Until this happens, renewable energy will need financial support if it is to compete against conventional alternatives, and to become established. A package of measures is in place, the centre-piece of which is the Renewables Obligation (and the equivalent Scottish Obligation). This sets a target for licensed electricity suppliers to provide 10% of electricity by 2010 from renewables technologies eligible under the Obligations. Compliance will be demonstrated by renewables obligation certificates (ROCs). Following statutory consultation on the detail of its proposals, the Government aims to put before Parliament the Order introducing the Obligations later this year.

Other support includes exemption of renewables from the Climate Change Levy; capital grants; and support for renewables r&d. Institutional factors are also being dealt with, through development of regional planning targets and work towards fair grid access for embedded generation.

especially the need to reduce greenhouse gas emissions. At the same time, if the saving in energy costs from energy efficiency improvements exceeds the costs associated with the improvements, then economic benefits will also be delivered.

A key activity in this resource productivity study and continuing in the energy review has been to identify the potential for these cost-effective energy efficiency improvements. In the business community, there is evidence to suggest that cost-effective energy savings assessed against current prices could amount to around 20–25% of current energy demand. In the domestic and transport sectors, the figure is more like 35–38%. Across the economy as a whole, this suggests that around 30% of total final energy demand could be removed

through cost-effective energy-saving measures – a potential annual cost reduction of around £12 billion, and a potential annual carbon saving of around 25% per annum.

There are many barriers to the take-up of energy efficiency

The obvious issue to address in response to these findings is the reason, or reasons, why this cost-effective potential is not being taken up. Initial findings suggest a series of market failures and barriers along the lines of those identified in section 1.4 of this report, for example:

- Most energy consumers have very imperfect information about energy efficiency opportunities.
- Energy users need to expend time and money to gather and assess information that is already available to energy suppliers and appliance manufacturers.
- Better information on capital costs than running costs leads to adverse selection of inefficient goods.
- Capital markets are incomplete for many borrowers.
- Inadequate contractual relationships with builders and other traders could mean projects may not be implemented correctly.
- Tenancy contracts and rental values provide split incentives for energy efficiency investment in rented properties.
- Non-corporate investment in the energy sector (almost exclusively on the demand side) has less beneficial fiscal treatment than corporate investment.
- Current regulations designed to promote competition preclude potentially beneficial long-term contracts between licensed energy suppliers and domestic customers.

In addition, the price of energy, in most cases, fails to take into account the environmental costs associated with its supply and use. In economic terms, there are externalities.

The result of all this is an untapped potential for energy efficiency. Given the estimated size of the economic and environmental benefits, there is a clear justification for Government intervention. And one very important point arising from the assessment of market failures is that unless ways can be found to address the other market failures directly, moves to raise energy prices to domestic customers are unlikely to have a significant impact on energy consumption.

This is not to say that prices have no role. But as explained in section 4.2.2, for market-based instruments as a whole, energy pricing will generally be more effective if implemented as part of a package of measures. More specifically, there are a whole host of structural barriers to energy efficiency, and these barriers cannot be overcome by measures typically classified as environmental. As the review continues, it will be addressing the full range of measures that can be brought to bear to remove the barriers, and increase take-up of cost-effective energy-saving measures. Measures that can also help to achieve other objectives of energy efficiency (e.g. reductions in fuel poverty) will be especially important.

Looking further ahead, it will become increasingly important to push forward the possibilities for cost-effective energy efficiency improvements. Closing the gap to what is currently cost-effective is unlikely to be enough if the UK as a whole is to meet its environmental objectives, while maintaining economic growth. This report's general recommendations for innovation policy will be reflected in more detailed recommendations in the review of energy policy for how Government can send the right signals for energy-saving innovation to occur.

3. UNDERSTANDING AND MEASURING RESOURCE PRODUCTIVITY

Summary

- **At face value, natural resources do not play a significant role in the national accounts or in productive processes. But this is potentially misleading. The contribution of natural resources – particularly those resources provided by pollution sinks – may be undervalued in the national accounts.**
- **Economic growth to date has been based around the use of natural resources to construct physical capital and make labour more productive. But we need to deepen our understanding of the role of natural resources in the economy and how to combine economic growth with protection of the environment.**
- **One area to explore will be the role of resource productivity in improving the overall productivity of UK business.**
- **It will also be important to develop the metrics available for measuring resource productivity, so that it becomes easier to track trends and make comparisons.**

3.1 The role of natural resources in the economy

The role of resources and resource productivity in the economy has been largely ignored in much of the mainstream literature on economic growth. The reason for this is that, at face value, natural resources contribute only a few percentage points of the national accounts.[58] But this statistic is potentially misleading. Within individual sectors and regions, natural resources can be much more significant. And the contribution of natural resources – particularly those resources provided by pollution sinks – may be undervalued in the national accounts.

Much of the UK and wider developed world's economic growth has been accompanied by the increasing use of fossil fuels and other resources. This reflects a so-called virtuous circle through which cheaper and more

[58] Figures available in ONS, "Annual Abstract of Statistics" (2001).

accessible fossil fuels and materials create rising incomes and increased returns to labour and capital, encouraging further substitution of resource inputs for more expensive alternatives.[59]

It is important to remember that not all natural resources play a similar role in the economy, and to clarify which natural resources are subject to the most pressures, and hence are of interest to policy-makers. This report focuses predominately on the very different challenges of greenhouse gas emissions and of waste, because the evidence suggests that these are currently the UK's most pressing environmental problems. But the approach and thinking adopted in this report can be applied much more widely.

Where resources are in relatively abundant world supply, and are not associated with significant adverse environmental impacts, there is little or no case for Government intervention. But as the OECD classification of environmental pressures suggests, there are a lot of resources that do not fit into this category. For example, climate change could put pressure on UK water supply in the south-east of England;[60] world fish stocks are already under considerable pressure;[61] and action has already been taken to improve the UK's aggregates efficiency.[62]

3.2 Links with productivity

Where labour and resources are used together, the evidence suggests that the relationship between resource productivity and labour productivity is mediated through the capital stock.[63] In very broad terms, new physical or human capital can be labour-enhancing, resource-enhancing or both. In order to exploit synergies and minimise trade-offs, the aim must be to deliver the last of these possibilities.

A key question is then whether or not these sorts of productivity improvements will be delivered under current policies. The simple answer is that we do not know, and we are unlikely to be able to obtain any clear answers in the future. However, in the context of considerable uncertainty about exactly what sort of structural changes will be required, it would be dangerous simply to assume that impacts will work in the desired direction. This is consistent with the precautionary principle, a key element of the Government's Sustainable Development Strategy (Annex C), which demands early preparation and the opening-up of options for the future, in situations of uncertainty.[64]

Resource productivity and labour productivity can be substitutes or complements

The historical virtuous circle of ever-cheaper resource inputs has meant that the past has been characterised by labour productivity improvements delivered through increased use of natural resources. The most obvious example is industrialisation and mechanisation of the western world economies through use of energy from fossil fuels. It is precisely this sort of pattern that is likely to prove unsustainable as we look forward over the next 50 years in the context of environmental limits such as those imposed by climate change. This is not to say that improvements

[59] These issues are explored in more detail in Ayres, RU, "Resources, Scarcity, Growth and the Environment", Centre for the Management of Environmental Resources, INSEAD, 2001.
[60] DETR (2000b), op cit.
[61] Wallis, P, "Changing Course to Responsible Fisheries", OECD Observer (2001).
[62] Council for the Protection of Rural England (CPRE), "Rocky Logic: The Role of Aggregates in the UK Economy" (1999).
[63] Mabey et al (1997), op cit.
[64] See also arguments in Elbasha, EH and Roe, TL, "On Endogenous Growth: The Implications of Environmental Externalities", Journal of Environmental Economics and Management (1996), which notes the importance of assessing resource and environmental impacts in order to measure welfare effects, rather than simply GDP effects.

in labour productivity should not be maintained. Rather, sustainable development requires that the improvements are delivered through increased use of intangible assets, or accompanied by appropriate improvements in resource productivity.

3.3 Measurement issues

Understanding the role of natural resources in the economy would be greatly facilitated by the availability of indicators that measure resource productivity. For individual resource inputs, such measures exist and are widely available. For example, information on GDP or value added per unit of energy used, or per unit of greenhouse gas emitted, is easily available at national and sectoral level within the UK. These can be thought of as directly analogous to the GDP per worker or per hour worked measures of labour productivity. Table 1 shows 1998 data on gross value added per unit of CO_2 for energy intensive industry. On average, for every one tonne of CO_2 emitted – the annual emissions from a typical car travelling around 8,000 kilometres per annum – the UK generates around £2,000 of value added. In other words, for every £1 million of value added in the UK economy, the UK currently has to emit 500 tonnes of CO_2.

Table 1: A measure of resource productivity in UK energy-intensive industry: gross value added per tonne of CO_2 emitted (GVA/CO_2)[65]

Sector	GVA/CO_2 (£000/tCO_2)
Electricity, gas, steam and hot water supply	0.1
Coke, refined petroleum products and nuclear fuel	0.1
Basic metals	0.1
Air transport	0.2
Water transport	0.2
Other non-metallic mineral products	0.3
Extraction of crude petroleum and natural gas	0.5
Land transport; transport via pipelines	0.6
Forestry, logging and related services	1.0
Chemicals and chemical products	1.0
Other mining and quarrying	1.0
Fishing, operation of fish hatcheries and farms	1.0
Agriculture, hunting and related services	1.7
Mining of coal and lignite; peat extraction	1.7
Food products and beverages	2.0
Wood and wood based products; articles of straw	2.0

[65] Table based on data taken from "Carbon Intensive Industry in the UK – A Paper for TUSDAC", DETR, May 2001. Calculations carried out by DETR, using 1998 data from ONS (environmental accounts and gross value added by industry).

But indicators such as this can only measure the productivity of one type of resource at a time. What would, in principle, be more helpful would be a single combined measure of the productivity with which the UK uses its natural resources. Such a measure would enable us to assess progress.

In practice, however, no such measure exists in a form that can be readily used and interpreted. A recent report for DEFRA assessed a number of different indicators of resource productivity that have been developed.[66] The conclusions from the report are discussed in further detail in Annex K. But the report found that not one of the measures scored highly against all of the criteria used to assess them in terms of robustness, practicality and usefulness to policy-makers.

3.4 Actions for progress

Simple actions to promote synergies in policy-making

Under the banner of sustainable development, Government needs to maintain a collective overview of the overall balance of signals being sent to the private sector. One way of doing this will be through the rigorous application of sustainability principles included in the HM Treasury "Green Book".[67] The Green Book includes comprehensive advice on how to undertake an assessment of environmental impacts. Its content is currently under review, and **it is recommended that HM Treasury and DEFRA should jointly promote and monitor the application of the guidance, particularly on appraisal of environmental impacts, to ensure that it is properly understood and applied.**

More generally, there will be a key role for price signals to create the incentives for labour productivity improvements that are synergistic with resource productivity. Section 4.2.2 expands on the role of economic instruments in delivering these signals. But the important point to note here is that unless the signals are sent, the private sector will undervalue natural resources in their decisions, leaving them with limited incentive to improve resource productivity.

Because of the limits to the effectiveness of direct price signals that can be sent in practice, this report argues that there is a case for supplementary action to tackle other barriers and to close the policy gaps left after the use of standard fiscal instruments. In the context of Government's Productivity Strategy, this means that **HM Treasury should continue to look for opportunities to target elements of the strategy in such a way as to jointly promote economic and environmental objectives.**

Improving our understanding of the role of natural resources in the economy

It is crucially important that we have a full understanding of the role that natural resources – particularly those subject to the most pressures – do play in the economy. **It is recommended that the ONS, DEFRA, DTI and HM Treasury work together on a programme of work to improve this understanding.** The programme will need to be focused on the development of the economy into the future, as well as on the present, exploring the implications for resource use and resource productivity. It should include the following elements:

[66] Moffatt, I, Hanley, N, Allen, S, Fundingsland, M, "Sustainable Prosperity: Measuring Resource Efficiency", Report to DETR (2001).
[67] HM Treasury, " 'The Green Book' – Appraisal and Evaluation in Central Government" (1997a), available at http://www.hm-treasury.gov.uk/guid.html.

- ONS should continue to work with DEFRA in developing the UK's environmental accounts as satellite accounts to the main National Accounts.
- DEFRA should seek to build on the work on material flow analysis already being carried out, including that funded by Biffaward,[68] in order to understand in particular the relationship between resource use in low-value-added primary sectors, and activity carried out in high-value-added intermediate and final sectors.
- Building on the work carried out by ONS (see above), HM Treasury and DEFRA should review and if necessary extend the empirical evidence relating to the levels of damage, expenditure and benefit linked to environmental impacts and environmental protection (see Annex F). What do we know about the way in which the environment impacts on labour and capital productivity? How much do we spend on environmental protection, and what benefits do we obtain?
- HM Treasury and DTI should continue to build on their understanding of the knowledge economy, identifying more clearly how the economy can grow without requiring more and more resource use. Does dematerialisation and reduced material throughput really hold the key? Or can some aspects of dematerialisation – such as the production of small, technology-intensive equipment – require high levels of resource use?
- HM Treasury, DTI and DEFRA should work together to address the likely impact of projected economic growth on resource use, resource productivity and the environment. A large part of this work – predominately relating to use of fossil fuels and to greenhouse gas emissions – will be carried out as part of the Government's review of energy policy. A similar methodology should be applied more generally once that piece of work is completed.

[68] Ekins, P and Linstead, C, "Mass Balance UK: Mapping UK Resource and Material Flows" (2001).

4. TOWARDS A RESOURCE PRODUCTIVITY STRATEGY

Summary

- **The long-term challenges of improving resource productivity and achieving sustainable development look likely to require some significant structural changes. These could in turn require some fundamental changes to policy and policy-making.**
- **Detailed assessment of these options will need to wait until we have improved our understanding of the issues, of the scale of the challenge and of the possible ways forward.**
- **There are some initiatives that will incur little or no cost, but which will begin to make a contribution to improvements in resource productivity.**
- **These initiatives include the development of long-term indicative targets for resource productivity and the environment; building on the Government's existing Statement of Intent on environmental taxation; targeting support for resource-productive innovation; redoubling efforts to incorporate sustainable development into Government procurement; and taking action to educate and engage the public.**

4.1 Issues for the longer term

The UK faces clear challenges, as discussed in depth in Chapter 1, if it is to develop the economy and protect the environment as part of its pathway towards sustainable development. Over the 50-year period considered in this report, there is a great deal of uncertainty. But it does appear that significant and long-term changes will be needed if environmental issues are not severely to constrain economic growth, and if economic growth is not going to come at an unacceptable environmental cost. Economic growth that damages the capacity of natural systems to absorb waste and pollution is unsustainable.

Improving resource productivity will not be sufficient on its own in delivering sustainable development, but could play a key role in delivering those significant and long-term changes that may be required. That potential is considered in Chapter 2. Perhaps most significantly, where there are firm limits imposed by environmental concerns, resource productivity improvements can help to ease the constraints those limits impose, enabling economic growth to be maintained. Probably the most important contributing factor will be innovation.

The recommendations made in this report are only a starting point. If the UK is to achieve the desired improvements in resource productivity, it will not happen quickly – and will not happen at all unless an active and coherent strategy is developed.

The good practice of evidence-based policy-making requires that we improve our understanding of the issues. However, decisions and action should not be postponed indefinitely, and the next chapter sets out a clear programme for taking this process forward and maintaining the UK's impetus.

Responsibility for sustainable development

One of the fundamental changes that may need to be considered in the future is the question of what body/bodies should take responsibility for sustainable development in the UK. At the moment, responsibility within central Government rests with DEFRA. But as the scale of the challenge increases, and if the need for significant structural changes is confirmed, there may be a case for taking responsibility more into the centre of Government. In addition, it is very clear that sustainable development requires a long-term perspective. It may be that this could be better achieved through some responsibilities lying outside bodies subject to the constraints of the political cycle.

This report stops short of recommending that this issue is taken forward at this stage. This will need to be revisited in the future in the light of experience and of other initiatives, such as the PIU review of energy policy. Models that might be considered include the following:

- Within central Government:
  - an Office for Sustainable Development along the lines of the Australian Greenhouse Gas Office;
  - a Cabinet Office-based delivery unit.
- Or outside central Government:
  - a Sustainable Development Select Committee with increased powers;
  - a role for the National Audit Office; or
  - a stronger role for the Sustainable Development Commission or other advisory bodies (for example, through a significant research capacity).

4.2 Issues for the present

Notwithstanding the need for further research, and the consequent need to wait until more fundamental changes to policy are implemented, there are a number of initiatives that could be taken forward now, at little or no cost, which would start to encourage and provide incentives for improvements in resource productivity. Some of these have been identified during the course of preceding chapters, and are summarised in Chapter 5. This chapter sets out the initiatives that will combine to form the remainder of the embryonic Resource Productivity Strategy.

4.2.1 A long-term policy framework

This report has made clear the importance of innovation in delivering sustainable development for the future. It has also

highlighted some of the structural changes that could be needed to avoid costly trade-offs between economic and environmental goals. The innovations and structural changes required will encompass technologies, infrastructure, institutions and culture. One of the key building blocks for delivering each of these will be some degree of clarity about the direction of policy in the long term.

For example, innovation is typically subject to relatively long lead times from initial basic research through to commercialisation. The report's assessment of the role of innovation in the liberalised electricity market (Annex J) has shown that without a clear framework for the long term, innovation will tend to focus on short-term commercial gains, rather than on long-term strategic development. This is unlikely to deliver the optimum route to sustainable development. And even when considering investment in new capital stock that is not necessarily innovative, a clear long-term framework is important when that capital stock will have a lifetime of 5–10 years or more.

Some uncertainty is inevitable, but Government can provide greater clarity

Of course, there are limits to the degree of long-term clarity that Government can provide. In the context of resource use and resource productivity, both Government and the private sector are unsure about exactly what pressures and constraints there will be in the long term. Perhaps the best example is provided by climate change, where the long time lags and complicated interactions make it very difficult to predict what impact emissions over the next 20 years will have on the world's climate over the next 100 years.

Attempting to put artificial limits on this uncertainty would be dangerous. But there is action that Government can take to reduce the risk and uncertainty associated with long-term innovations and investments. Three possible areas are:

- Government is best placed to reduce risk and uncertainty associated with the political cycle. Although no Government can bind its successor, there are ways of reducing the uncertainty that can arise from electoral changes. One example is the way in which the Bank of England was made independent and given autonomy in determining monetary policy to deliver a specified target. This has greatly reduced uncertainty in the macroeconomic climate.
- Government should undertake its activities in the context of the precautionary principle. Where there is uncertainty about future events or impacts, but there are well-founded grounds for believing that the impacts may be significant, action should be taken to prepare for the range of eventualities, particularly those at the worse end of the spectrum. Of course, any action should be assessed in terms of costs and benefits. But the precautionary principle does suggest that Government should be putting in place policies to ensure preparedness against the full range of possible eventualities. To take an example from climate change, this would involve being prepared not only for adverse climate impacts, but also for the need to undertake greater than expected emission reductions.
- Government can often inform the private sector about risk and uncertainty. Even when knowledge does exist, levels of risk and uncertainty can be exacerbated by lack of awareness if that knowledge has not been disseminated. This is why the Government has devoted the opening sections of its Climate Change Programme to information about climate change and what it might mean, and why it has been actively promoting the information to schools.

Government has already accepted these principles in its policy-making process, particularly through the way in which it is carrying forward its Sustainable Development Strategy (see Annex C). **DEFRA should take responsibility for disseminating these principles and ensuring that they are implemented in policy-making across all departments.**

Adopting long-term indicative targets for the environment and resource productivity

In addition, there may be a case for adopting and moving towards long-term indicative targets that would help to establish greater certainty about the long-term path to sustainable development. The justification for any targets would need to be established on a case-by-case basis, using cost-benefit analysis. And any targets should reflect the precautionary principle, be flexible, and should contribute to more general awareness of the need for change. There will be a case for choosing similar indicators to other countries, to facilitate international comparison. **This report recommends that DEFRA and DTI should draw on the results of work cited and recommended in Chapter 3 of this project, along with the existing sustainable development indicators, to examine the case for long-term indicative targets across a range of indicators.**

One model for these could be the targets for 2030 recently adopted by the Dutch Government, across a range of different environmental indicators.[69] The Dutch targets are all in the form of ranges of emission reductions required relative to 1990 levels. The targets are not meant to be legally binding, but do indicate the scale of the changes that will be required. They are also accompanied by an assessment of the seven major environmental challenges faced in the Netherlands.

One particular issue for consideration will be the relative merits of emissions targets (the Dutch approach) versus resource productivity targets. Of course, the two types of target are complements rather than substitutes. And both can help to set the framework for resource productivity improvements and for the achievement of sustainable development. But while explicit resource productivity targets may be more directly focused on this goal, clarity and ease of measurement may instead suggest use of emissions targets, at least for the time being.

4.2.2 The role of market-based instruments

Government has already identified the importance of market-based instruments in taking the UK towards sustainable development. The "Statement of Intent on Environmental Taxation" published in July 1997[70] stated that the Government would "aim to reform the tax system to increase incentives to reduce environmental damage". The purpose of this would be to "shift the burden of tax from 'goods' to 'bads'; encourage innovation in meeting higher environmental standards; and deliver a more dynamic economy and a cleaner environment, to the benefit of everyone". While regulation is often most effective in bringing performance up to a standard, it is price signals that tend to push performance beyond current standards.

Policies developed since the Statement of Intent have the potential to play a key role in improving resource productivity and delivering sustainable development. Examples include the Climate Change Levy, the aggregates tax and road fuel duty. Chapter 1

[69] "Environment Daily 1009", 14 June 2001.
[70] HM Treasury (1997), op cit.

identified the presence of external costs and benefits as a key barrier to resource productivity improvements. Internalisation of external costs through environmental taxation is an efficient way of overcoming this barrier.

However, the Statement of Intent also noted that environmental taxation must meet the general tests of good taxation. That is to say, "*it must be well designed, to meet objectives without undesirable side-effects; it must keep deadweight compliance costs to a minimum; distributional impact must be acceptable; and care must be had to implications for international competitiveness*". These concerns have been raised in a number of existing examples of environmental or environment-related taxation, and action has been taken as a result or policy designed accordingly. For example, VAT on domestic fuel has been reduced due to unacceptable social impacts, and the Climate Change Levy package was designed to deliver environmental objectives without damaging competitiveness.

The role of environmental taxation

Because of these wider considerations, it has not always been possible to internalise fully all of the external costs associated with economic activity. This is a rational response to the multiple objectives of sustainable development. Moreover, it is not always possible to obtain sensible estimates of external costs. But it does leave a problem where we are faced with limits associated with environmental issues. These can be those imposed by the physical environment itself, or those imposed by national, European or international targets set in response to the costs of environmental damage.

In addition, even where external environmental costs are internalised, this will not necessarily be sufficient to meet environmental targets. There are two possible reasons why this might not be the case:

- The first is that the targets may have been set at a level beyond that justified by the external costs. In the presence of uncertainty about future impacts, this may in some circumstances be justified by the precautionary principle. But it may be that the target is simply too high, and that the benefits of achieving the target do not balance the costs incurred. Where targets are already enshrined in law, there may be little option other than to find the least-cost way of achieving the target. But for the future, it will be important to set targets on the basis of a proper analysis of the costs and benefits (including the targets proposed in section 4.2.1).
- The second is that there are other barriers that are preventing an efficient response to the signal provided by the internalisation of external costs. This could arise as a result of any of the other barriers identified in Chapter 1, which draws heavily on work carried out in relation to energy efficiency. The example of the landfill tax also highlights this issue (Box 6). Barriers such as the lack of markets for recyclate, information failures and limited cost pass-through have all acted to limit the behavioural response.

Wider application of the Statement of Intent

In the light of these observations, and the experience provided by those environmental taxes introduced to date, **it is recommended that HM Treasury should work with other departments to consider how it could apply the principles within the Statement of Intent to issues arising with other economic instruments.**

Box 6: Resource productivity and waste

"Dealing with waste" (Annex G) highlights a number of ways in which waste reduction, as part of wider efforts to improve resource productivity, can help contribute to economic growth as well as deliver environmental benefits.

The generation of waste has tended to be bound up with economic activity. There is a need to decouple waste from economic growth in order to move from current levels of waste arisings to the levels required by the EU Landfill Directive, and what will be required in future to deliver a sustainable economy. By tackling waste in the context of resource productivity, and looking explicitly at how we can generate more value added while using fewer resources and creating less waste, it should be possible to design policy in order to minimise negative trade-offs and maximise positive synergies. For example, experience from work carried out by Envirowise (see Box 1 and Annex G) has shown the potential for industry to cut down on waste while improving cost-effectiveness.

Government has already taken the major step of reflecting the external costs of landfill through the introduction of the landfill tax. This has been accompanied by a number of other measures, which are seeking to overcome the barriers to improving the effectiveness with which we manage our resources and deal with our waste. But because the "waste life cycle" is complicated, and barriers along the lines of those set out in section 1.4.1 are pervasive, progress towards the targets imposed by the Landfill Directive has been slow.

Areas for possible action set out in Annex G will feed into future work by DEFRA, HM Treasury and others on the tools and levers which can be used to deliver our targets for waste. PIU will also:

- contribute to any future work by relevant departments on developing positive measures to help firms and local authorities to manage recycling and other targets, be this through fiscal or other means to help motivate behavioural change;
- encourage the use of bodies such as WRAP and Envirowise as sounding boards for closing the gap between policy formation and implementation on the ground;
- continue working with other departments and the Office of Government Commerce to further promote good waste management in procurement (see section 4.2.4), using public procurement as an exemplar; and
- undertake some further analysis on waste streams and the implications for energy choices as part of the review of energy policy.

Examples of the other instruments will include tradable permits (currently being implemented in the UK for greenhouse gas emissions, and planned for other environmental policy areas) and tax incentives or differentials (such as the enhanced first-year capital allowances for energy-efficient investment, announced as part of the Climate Change Levy package). These are already being introduced on an ad hoc basis, where they are considered to be complementary to or more appropriate than environmental taxation. But it would be useful to have a clear statement of policy to

ensure that they meet similar tests to those applied to environmental taxation.

Key areas where the principles from the Statement of Intent should be applied include the following:

- Ensuring that other economic instruments meet the basic economic rationale set out for environmental taxation in the Statement of Intent on Environmental Taxation, i.e. that they should aim to reflect external costs of environmental damage.
- Ensuring that other economic instruments need to meet similar tests to those that determine whether tax measures, including tax incentives, meet the tests of "good taxation". This may point to a "package" approach, which could enable economic instruments to stand up more effectively against the tests of meeting objectives and keeping deadweight compliance costs at a minimum. The Climate Change Levy package provides a good example of this approach, for example by recycling some of the revenues raised by the tax to other measures that will improve its effectiveness.
- Taking account of the distributional impacts of other economic instruments. The package approach could also be appropriate here, perhaps through transitional arrangements. There can often be a very significant step between the starting point, and full internalisation of external costs, and this needs to be explicitly addressed in policy design.[71]

4.2.3 Targeting innovation

This report has made very clear the role of innovation in delivering sustainable development in the UK. The importance of innovation more generally has also been recognised by Government, for example through the publication of a consultation paper entitled "Increasing Innovation"[72] alongside Budget 2001. But that paper focused on the role of innovation and research and development as "catalysts for productivity growth" and "in maintaining [...] high and stable growth".[73] In contrast, the question for this report is this: will the current policy climate deliver innovation that will ensure a resource productive future, helping the UK towards sustainable development?

Most innovation and r&d is performed by the private sector, driven by commercial opportunities and pressures. Hence it is only where markets fail or where barriers exist that Governments need to intervene in respect of setting an appropriate policy climate. Many of the barriers to resource productive innovation will be tackled by the more general action to encourage innovation that has been outlined in "Increasing Innovation". In addition, greater clarity in the long-term policy framework (section 4.2.1) and internalisation of externalities (section 4.2.2) will both help to create the right incentives for innovation to proceed in an appropriate direction.

Further action focused on delivering resource productive innovation

However, there remains a case for more focused action to promote innovation in the context of resource productivity. There are three key reasons for this:

[71] One way of dealing with this may be to focus in the first instance on price signals at the margin – which is what will prompt behavioural change – while avoiding large transfer payments. For example, it is proposed that the Government's greenhouse gas emissions trading scheme will feature free allocation of allowances up to the level of a target, meaning that companies have every incentive to reduce emissions, but are not faced with a lump sum transfer in relation to emissions that were previously "costless".

[72] HM Treasury and Inland Revenue, "Increasing Innovation – A Consultation Document" (2001).

[73] HM Treasury and Inland Revenue (2001), page 1, op cit.

- There are some specific barriers relating to innovation that will improve resource productivity. One of the most significant is the fact that the "market" for these types of innovations will nearly always require a framework of incentives provided by Government, rather than arising naturally from commercial activity.
- Government is often constrained in its implementation of what economists would term "first-best" environmental policies. If this is the case, targeted action on innovation may be a "second-best" option.[74]
- Looking to the long term, there are clear economic arguments for very low discount rates[75] when dealing with natural resources and with inter-generational issues.[76] Such low discount rates will not be applied by the private sector.

This suggests that there is a case for targeting some innovation towards improvements in resource productivity. Care needs to be taken, as there will be an opportunity cost to this, through the diversion of innovation (or some other form of expenditure) from elsewhere. Detailed analysis of specific options is beyond the scope of this report. **It is therefore recommended that DTI, HM Treasury and DEFRA review the options for targeted support for resource productive innovation, throughout the innovation cycle.** Some specific areas to address will include:

- The role of incentives to stimulate market activity. Any subsidies should be gradually reduced and then eliminated as the technology becomes increasingly commercially viable. Time scales for this phasing out will vary between technologies, but should be agreed in advance of their implementation. Measures of success, pointing to an exit strategy for Government support, should be agreed in advance. Any competitions should be judged on economic and technical criteria by independent experts.
- Creation of niche markets that enable new products and practices to benefit from learning by doing and gain economies of scale. Niche markets may be established through greening procurement (see section 4.2.4) or even through environmental regulation. Guaranteed niche markets can be a powerful stimulus for innovation.
- Economic externalities, high transaction costs, or bounded rationality may prevent resource productive technologies from being widely diffused through the market.[77] Policy instruments recognised as being particularly effective in encouraging diffusion include investment subsidies, information dissemination and voluntary agreements.[78] The limited take-up of available energy-efficient technologies is a classic example of where Government support for technological diffusion is appropriate.

[74] The "first-best" solution referred to by economists is one in which all prices are adjusted by economic instruments to reflect the full costs and benefits faced by society. Where this cannot be achieved, economists refer to a "second-best" solution, in which alternative measures are introduced as proxies for the economic instruments.

[75] Discount rates are applied to costs and benefits that occur in the future, and reflect the fact that holding money today is more valuable than the promise of money in the future. The private sector typically uses an annual discount rate (or "hurdle rate") in double figures. The "Green Book" (HMT (1997a), op cit) recommends that the public sector should use 6%, but allows the use of lower rates in certain circumstances.

[76] See, for example, Rothenberg, J, "Economic Perspectives on Time Comparisons: An Evaluation of Time Discounting", in Choucri, N (ed.), *Global Accord: Environmental Challenges and International Responses*, MIT Press, Cambridge (1993).

[77] Envirowise and the proposed Green Technology Challenge are examples of two resource productivity related Government initiatives that support diffusion of best practice technologies. In the last year alone, the Envirowise Programme helped UK businesses save more than £100 million through increased resource productivity. See http://www.envirowise.gov.uk/ for more information.

[78] See POST, "Cleaning Up? Stimulation Innovation in Environmental Technology", Report Number 136 (2000). HM Treasury and Inland Revenue (2001), op cit, explains diffusion policies as "Government helping to disseminate knowledge and new technologies through the economy to raise awareness of the potential for further R&D and innovation."

- A comprehensive assessment should be made of the role of regulatory standards and the factors that are taken into account in determining those standards. Standards should be outcome based and increase gradually over time to encourage ongoing improvement. Ambitious goals may be required to stimulate real change. Unambitious regulation is more likely to result in technology diffusion, not innovation, though diffusion can be an appropriate policy goal in some circumstances.[79] Industry incumbents should not be allowed to unduly influence regulations, as this will tend to disadvantage new entrants.[80] Voluntary agreements should also avoid this pitfall, in addition to being backed up by a credible threat of regulation if a satisfactory agreement cannot be negotiated.
- An assessment should be made of possible programmes to encourage basic research in areas that will deliver resource productivity improvements. This will be essential if the foundations are to be laid for a resource productive future.

4.2.4 Leading by example

Government's key role is to put in place a framework of signals and incentives that will deliver sustainable development. But it is important that at the same time, Government remembers to put its own house in order. This means that Government's own activities, including its approach to procurement of goods and services, should reflect its priorities for sustainability and the environment.

Government procurement was highlighted in a recent PIU report on social, health, environmental and trade objectives on a global stage.[81] It is also highlighted in the PIU report on workforce development.[82] Making sure that Government policy objectives on sustainability are appropriately reflected in Government procurement can deliver two key benefits:

- It enables Government to lead by example and to be consistent in the messages it sends to the private sector, hence demonstrating the importance attached to policy goals.
- Where Government is a major player in the particular market in question, Government procurement activity can affect that market in a desirable manner.

Limits to what procurement can deliver

However, it is important to recognise what Government procurement cannot do. Most importantly, public procurement is not a substitute for policy focused specifically on resource productivity, sustainable development or the environment, or for policy affecting the whole target community rather than only those to whom Government happens to be awarding contracts. The objective of the Government's procurement policy is to deliver value for money for the taxpayer. Value for money is not the lowest price: it is defined as "the optimum combination of whole-life cost and quality to meet the user's requirement".[83] There are also EC procurement rules, which are consistent with this value for money policy and which

[79] Similarly, taxes and subsidies, in the absence of any larger policy framework, may provide too weak a stimulus for innovation but be quite effective in promoting diffusion. See OECD, "Technological Change, Public Policy and the Environment" (2000), page 44.

[80] Regulation in Europe, which is often designed with industry consensus, has been shown to be less innovation inducing than regulation in the US. See Ashford, NA, "An Innovation-Based Strategy for a Sustainable Environment", in Hemmelskamp, J, Rennings, K and Leone, F (eds.), *Innovation Oriented Environmental Regulation*, Heidelberg: Physica-Verlag (2000). Industry incumbents also tend to overstate the costs of complying with new regulations, often by a factor of three to five. See Ashford (2000), op cit, and Porter, M and van der Linde, C, "Green and Competitive: Ending the Stalemate", Harvard Business Review vol 73 (1995).

[81] PIU (2000), op cit.

[82] Papers available at http://www.cabinet-office.gov.uk/innovation/2001/workforce/development.shtml.

[83] Annex 22.1 of HM Treasury, "Government Accounting 2000: A Guide to Accounting and Financial Procedures for the use of Government Departments" (2000).

apply across the whole of the public sector. These rules are enforceable by action by aggrieved suppliers in the UK courts and by the European Commission in the European Court of Justice.

Within the current legal framework for Government procurement, there is much that can be done to support sustainable development goals. Action has already been taken to weave environmental issues into the concept of "whole life costs". Joint HM Treasury/DETR (now DEFRA) guidance issued in March 1999 sets out what is and is not feasible at each stage of the procurement process, from specification, through selection of tenderers to award of contract and contract conditions.[84] This guidance is very similar to the subsequent interpretative document issued by the European Commission, which sets out what is and is not allowed under EC procurement rules.[85]

The primary message of that guidance is that there is considerable scope for encouraging resource productive and environmentally beneficial activities using procurement. But the key is to take the right action at the right stage of the procurement process. For example, there is considerable scope to require resource productive activities in the specification of the goods or service required. And where environmental management is relevant to the goods or service, this can be used in selecting tenderers. At the award stage, only value for money criteria can be used in evaluating bids. But, as this will include whole life costs and quality criteria, issues such as energy savings from investment in energy-efficient goods, recyclability and disposal can be taken into account. One underrated stage of the procurement process is the carrying out of the contract, during which Government departments have an excellent opportunity to influence their suppliers by working in partnership with them in a voluntary framework.

One area where progress has been made is in Government's procurement of construction. Central and local Government procures some 40% of the construction industry's outputs. As a major client of the construction industry, sustainable principles have been embedded in its procurement strategy. A sustainability action plan – "Achieving Sustainability in Construction Procurement" – published by DETR in June 2000 set out robust targets for improving the sustainability of new Government contracted works by March 2003.

Wider dissemination and uptake of the existing guidance

The Government's commitment to sustainable development extends across all departments, and every department has a responsibility to ensure that it is aware of the potential for taking sustainable development into account in procurement. Of course, in order to do this, departments need to be aware of what is and is not permissible. The responsibility for this lies not with the Office of Government Commerce (OGC) or with the procurers themselves, but with DEFRA and the networks of Green Ministers and Green officials covering all central Government departments. There does seem to be a problem in that procurers are not being given enough direction, or sufficient advice, in implementing the guidance and exploiting the opportunities that are available.

[84] HM Treasury and DETR, "Environmental Issues in Purchasing", guidance note (2000).
[85] Commission of the European Union, "Commission Interpretative Document on the Community law applicable to public procurement, and the possibilities for integrating environmental considerations into public procurement", COM (2001), 274.

Box 7: Designing sustainability into capital projects. Experiences from the National Museum for Science and Industry

The National Museum for Science and Industry (NMSI) is responsible for the Science Museum in London, the National Railway Museum in York and the National Museum of Photography, Film and Television in Bradford. It also owns a number of other sites, and has been looking to develop its site at Shildon in County Durham in a way that is consistent with sustainable development. The experiences of the NMSI in the project give an indication of the room for improvement.

Funding for the Shildon site would come from a variety of different sources, including local Government, the National Lottery, national Government and Europe. Each of these sources has its own particular measure of what would be termed a "successful" development. None of the measures directly incorporates sustainability as an important outcome, and only some (most notably national Government) are interested in savings in running costs from use of, for example, energy-efficient materials and machines. If the up-front cost of sustainable development is greater than the unsustainable alternatives, an organisation such as NMSI will have its work cut out in trying to build for a sustainable future. This is made even more difficult by the lack of clear guidance on where to go for advice on "buying green".

It is recommended that DEFRA should put to Green Ministers a programme of action for ensuring that procurers in every department:

- are aware of the existing guidance and what it means;
- are aware of the importance of operating procurement within a sustainable development context, and of the scope for doing so; and
- know where to go to for advice – either within DEFRA, or within wider initiatives such as the Market Transformation Programme, WRAP, the Energy Saving Trust or Energy Efficiency Best Practice Programme (EEBPP).

One option would be for Government departments to report annually on their policies and progress in sustainable procurement, perhaps as part of the more comprehensive reporting raised in the discussion of corporate social responsibility in Chapter 2.

Looking further ahead, **DEFRA should continue to work with OGC and other departments to ensure that issues relating to sustainable development are appropriately addressed in any future rounds of discussions on EC and international procurement rules.**

4.2.5 Achieving cultural change

Cultural change will be a key part of moving towards sustainable development. This report has shown that significant step changes will be needed over the next few decades, in terms of the way in which we all carry out our activities. As part of this, we will need to take forward and adapt to a significant number of technological, institutional and social innovations. If the households, companies and organisations of the UK are going to accept and be comfortable with these changes, it will be essential that they understand and accept their role and purpose. Without this, the effectiveness

Box 8: Engaging individuals, delivering change

Simply getting people to think about the way in which they use and abuse natural resources will be one of the key elements of delivering cultural change. Information provision will be one part of this. But much more is required if individuals are going to become truly engaged in the resource productivity challenge.

The Science Museum has been pioneering this approach to interactive information-sharing in its exhibitions on a number of key issues facing 21st century Britain. Instead of just providing abstract facts, the Science Museum's approach places the visitor at the centre of the issues concerned. By doing so, the Museum encourages direct participation in the debate on these issues, and promotes the realisation that individual contributions can make a difference.

Examples include:

- "Tell us what you think", electronic exhibits located throughout the Science Museum's Wellcome Wing, where individuals can read what other people think about controversial issues, then type in their own comments.
- Proposals for a new "Renewable Energy Roof" with solar panels and a wind turbine which, while making the museum more sustainable, will also power exhibits where visitors can discuss sustainability, energy use and climate change.
- The Dana Centre in the Wellcome-Wolfson Building, due to open in early 2003, which will house cutting-edge debate on some of the most controversial issues affecting modern society, aimed especially at young adults.

of policy will be constrained, and the road towards sustainable development will be beset with problems rather than opportunities.

Of course, no single measure will deliver cultural change. Each of the other measures discussed above will have a part to play in changing the way we think about our use of resources, and our impact on the environment. Key among these will be the clearer signals being sent about the direction of policy in the long term, and the example provided by the way in which Government carries out its own business. But there are some additional things that can be done.

Experience from the study of energy efficiency shows that raising awareness is key. There are many organisations providing information on energy efficiency. **It is recommended that the Government's review of energy policy, being carried out by the PIU, assesses the effectiveness of these various bodies.** Although each of the bodies has its own *raison d'être*, evidence from the experience of small businesses suggests that the number of actors is causing confusion. Lessons from energy efficiency will also be applicable to other areas, such as the role of Envirowise in reducing waste generation.

But provision of information on its own is unlikely to be enough. Individuals are much more likely to change their behaviour if they are given the opportunity and the space to assess the facts, and to reach their own conclusions with regard to the impact of their resource use on the environment.

It is recommended that DEFRA liaise with DCMS in drawing lessons from the experience of the Science Museum, in terms of its programmes for encouraging direct participation and debate. This sort of approach seems to have merit in properly engaging the public in a discussion about the important issues relating to sustainable development and quality of life.

There are many other examples that could be drawn on to provide good examples of public engagement at local level (such as the work of the Groundwork Trusts or Local Agenda 21). The evidence strongly suggests that a sense of trust and emotional engagement with an institution or a cause is essential in increasing people's propensity to respond in a positive manner.

It will also be important to draw on recent work sponsored by the Joseph Rowntree Foundation, which suggests that particular efforts need to be made in engaging with disadvantaged groups in their local situations and local concerns, before they can be expected to prioritise national and global issues.[86]

Education and training also need to play a role

Another important contribution to delivering cultural change will come from improved education and training in relation to resource productivity and sustainable development. One area where future action may be appropriate is in relation to the new Sector Skills Councils announced earlier this year.[87] In responding to the earlier consultation on National Training Organisations (NTOs),[88] on which Sector Skills Councils are intended to build, ACBE, TUSDAC and the SDEP[89] recommended that NTOs could have a role in taking forward sustainable development issues. They recommended that sustainable development should be at the heart of a strengthened NTO network and that education and training on sustainable development needed to be identified as a core role for all NTOs in guidance issued to them. This would have the twin benefits of engaging individuals at the same time as the companies and organisations for which they work.

The new Sector Skills Councils will not have an explicit remit for sustainable development, though their more general work on skills, investment and innovation will all be beneficial. **This report recommends that after the transitional phase, during which the Sector Skills Councils will be established, DfES and DEFRA should consider whether promotion of sustainable development themes could be a future role for the Councils.**

[86] Burningham, Kate and Thrush, Diana "The environmental concerns of disadvantaged groups", University of Surrey for Joseph Rowntree Foundation, September 2001.
[87] DfES, "Meeting the Sector Skills and Productivity Challenge" (2001).
[88] "Building a Stronger Network: Developing the Role of National Training Organisations", Department for Education and Employment (2000), also available at http://www.dfes.gov.uk/consultations/archive/archive1.cfm?CONID=46.
[89] Advisory Committee on Business and the Environment; Trade Union Sustainable Development Advisory Committee; Sustainable Development Education Panel.

5. WHAT HAPPENS NEXT? IMPLEMENTATION AND DISSEMINATION

Summary

- **This report has set out the issues surrounding the role of resource productivity improvements in delivering sustainable development, and the policy insights that can be gained from the concept of resource productivity. The recommendations in this report follow directly from the assessment undertaken.**
- **DEFRA will take the lead in considering these recommendations, and taking forward work to improve our understanding of the role of resources and resource productivity in achieving sustainable development. DEFRA will work with DTI and HM Treasury, and will consult with other central, devolved and regional Government bodies and agencies as appropriate.**
- **DEFRA will also take the lead in disseminating the conclusions of this report, and of the ongoing analysis. DEFRA will work with the FCO and DTI in sharing expertise and analysis with the European Commission and the OECD, and in preparing an input to the World Summit on Sustainable Development in September 2002.**

Improving resource productivity is likely to be a vital element of a long-term transition to a sustainable economy in which growth in wealth and quality of life are decoupled from growth in waste, pollution and carbon emissions. Making the most of the enormous economic and technological potential they represent is among the biggest challenges facing Government, business and citizens – but also the greatest opportunity for a better quality of life for future generations.

To this end, it is important that the Government builds on the foundations laid in this report. This section sets out what needs to happen next in terms of implementation and dissemination.

5.1 Summary of recommendations

Table 2 summarises the key recommendations to Government that are set out in this report. The table states what the recommendation requires, which department should be responsible for taking forward the recommendations, and when and how progress should be assessed.

Table 2: Summary of report recommendations and implementation

Section	Recommendation	Lead dept.[90]	Other depts. to be involved	Measuring and making progress
2.3	**DEFRA** and **DTI** to keep environmental reporting guidelines under review; uptake of environmental reporting to be monitored against objectives	DEFRA/DTI	HMT/DFID	Extent to which leading 350 quoted companies in the UK have taken up environmental reporting by end-2001. More general assessment of effectiveness of voluntary and CLR initiatives in encouraging take-up. Liaison with business to identify barriers to take-up.
2.5.1	**DEFRA** to evaluate the international aspects of UK environmental improvement to date	DEFRA	DTI, HMT, ONS, FCO, DFID	Paper to be disseminated setting out the evidence on links between environmental policies and competitiveness in the past, and prospects for the future in the context of resource productivity.
2.5.2	**Inter-departmental** economists' group to identify systemic barriers to resource productivity, and suggest how they might be overcome	DEFRA/DTI/ HMT	FCO/ONS/ DFID/DTLR	Early identification and implementation of specific policy proposals to overcome barriers to resource productivity. Dissemination of more general conclusions on use of resource productivity in informing policy-making.
3.4	**HMT** to promote guidance contained in "Green Book", to ensure that environmental issues, and sustainability issues more generally, are incorporated in policy appraisal	HMT	DEFRA	All policy appraisals to explicitly address environmental/ sustainability issues wherever relevant. Possible use of Green Ministers network to promote good practice.

[90] DEFRA = Department for Environment, Food and Rural Affairs, DTI = Department of Trade and Industry, HMT = Her Majesty's Treasury, FCO = Foreign and Commonwealth Office, DFID = Department for International Development, ONS = Office for National Statistics, OGC = Office of Government Commerce, DCMS = Department for Culture, Media and Sport, DfES = Department for Education and Skills, DTLR = Department for Transport, Local Government and the Regions.

Section	Recommendation	Lead dept.	Other depts. to be involved	Measuring and making progress
3.4	**HMT** to consider areas where Productivity Strategy can jointly promote economic and environmental objectives	HMT	–	Progress to be linked to Budget/ Pre-Budget Reports. Aim to identify and implement specific policies wherever possible, such that productivity improvements are delivered across all inputs, including resources.
3.4	**DEFRA** to lead on programme aimed at improving our understanding of the role of natural resources in the economy	DEFRA	DTI, HMT, ONS	Development of work on environmental accounts and material flow analysis; papers setting out role of resources in the economy to be disseminated for discussion. Progress and specific areas of analysis to be kept under review.
4.2.1	**DEFRA** to disseminate key principles underlying the sustainable development strategy, particularly the precautionary principle	DEFRA	–	Good practice to be disseminated, possibly using Green Ministers network. Needs to be clear evidence that departments are incorporating principles of sustainable development in their policy development.
4.2.1	**DEFRA** to assess the case for long-term indicative targets on a range of indicators relating to environmental and resource productivity	DEFRA	DTI	Aim to publish consultation paper within one year.
4.2.2	**HMT** to work with other departments in applying the principles from the existing Statement of Intent on Environmental Taxation to wider economic instruments	HMT	–	Aim to publish early guidance on use of wider economic instruments, drawing on existing Statement of Intent.
4.2.3	**DTI** to review the options for targeted support for innovation to deliver resource productivity	DTI	HMT, DEFRA	Aim to identify and announce specific measures that will boost innovation aimed at improving resource productivity.
4.2.4	**DEFRA** to lead a programme of action ensuring that procurers in every Government department are aware of guidance on incorporating sustainability into procurement, and are actively implementing the guidance	DEFRA	–	Put to Green Ministers a set of specific proposals for implementation across Whitehall.

Section	Recommendation	Lead dept.	Other depts. to be involved	Measuring and making progress
4.2.4	**DEFRA** to take continued action to ensure that issues relating to sustainable development are addressed in future rounds of discussion on EC and international procurement rules	DEFRA	OGC	Ensure that sustainable development issues are explicitly addressed in debate surrounding future procurement rules.
4.2.5	**PIU** to include within review of energy policy assessment of the effectiveness of the various information-providing bodies, with a view to possible recommendations on structure	PIU	DTI, DEFRA	Recommendations to be made in the review's final report.
4.2.5	**DEFRA** to apply to sustainable development awareness-raising the lessons learned from the Science Museum's experience	DEFRA	DCMS	Awareness-raising programmes to be revised accordingly in the light of evidence on how best to engage individuals and communities.
4.2.5	**DfES** and **DEFRA** to consider a future role for Sector Skills Councils in explicitly promoting sustainable development themes	DfES, DEFRA	DTI	Needs to be revisited after the transition phase for the new Sector Skills Councils.
Annex E	**DEFRA** and **DTI** to develop a focused sustainable development approach for small businesses, based around improvements in resource productivity that will benefit small businesses as well as contributing to sustainable development goals	DEFRA/DTI	Small Business Service	Barriers to be identified and targeted action to be taken that will help small businesses improve their resource productivity and contribute more effectively to sustainable development goals.
Annex K	**DEFRA** to develop simple proxy measures of resource productivity for the short term	DEFRA	ONS, DTI	Proxy measures to be developed, published and used to inform policy-making.
Annex K	**DEFRA** to develop more detailed measures and more refined measurement techniques relating to resource productivity in the longer term	DEFRA	ONS, DTI	Requires identification of agreed values for environmental damage, and agreed techniques for measuring resource flows and resource productivity.

5.2 Implementation programme: responsibilities and timetable

Government has agreed that the questions of whether, how and when it will be most appropriate to implement these recommendations will be overseen by a steering group established in the first instance by the PIU, but taking its membership from the three key departments in relation to resource productivity – DEFRA, DTI and HM Treasury. Once the group is established, the lead role will sit most appropriately with DEFRA. This steering group will consist of members at director-level, and should meet once every quarter to assess progress and discuss next steps. The steering group will be supported by a secretariat responsible for ongoing oversight of the report implementation programme.

Each of the recommendations is likely to proceed to a slightly different timescale, but the steering group will wish to tie its activities in particular to some key milestones:

- **Autumn 2001**: Pre-Budget Report 2001.
- **End-2001**: Completion of DG ENV[91] studies on the role of environmental technology and innovation in contributing to economic growth and employment; and on sustainability impact assessment.
- **End-2001**: PIU review of energy policy presented to Prime Minister.
- **Spring 2002**: Budget 2002.
- **Mid-2002**: EC publish Green Paper on Resource Productivity (see below).
- **Mid-2002**: Spending Review 2002.
- **September 2002**: World Summit on Sustainable Development (see below).
- **2003**: EC publish White Paper on Resource Productivity.

[91] DG Environment at the European Commission.

5.3 Dissemination and co-operation

The second role of the steering group and secretariat will be to disseminate the report and its findings within the UK and abroad. There will be several elements to this:

- Dissemination of good practice within central Government departments, Government agencies and devolved/regional bodies.
- Engagement with business, NGOs, academics and think-tanks to take forward our understanding of the issues.
- Co-operation with international bodies and initiatives focusing on resource productivity. Key among these will be the EU Sustainable Development Strategy, to be finalised at the Barcelona Summit in early 2002. Resource productivity is expected to be a major theme. It will also be important to engage with G8 work in the run-up to the World Summit on Sustainable Development (WSSD) due to take place in Johannesburg in September 2002. There are also initiatives under way in the OECD on which mutual sharing of expertise would be helpful. FCO and DFID will have a key role in taking this work forward.

ANNEX A: THE ROLE OF THE PERFORMANCE AND INNOVATION UNIT

The creation of the Performance and Innovation Unit (PIU) was announced by the Prime Minister on 28 July 1998 as part of the changes following a review of the effectiveness of the centre of Government by the Cabinet Secretary, Sir Richard Wilson.

The PIU's aim is to improve the capacity of Government to address strategic, cross-cutting issues and promote innovation in the development of policy and in the delivery of the Government's objectives. The PIU is part of the drive for better, more joined-up Government. It acts as a resource for the whole of Government, tackling issues that cross public sector institutional boundaries on a project basis.

The PIU reports direct to the Prime Minister through Sir Richard Wilson. A small central team helps recommend project subjects and manages the Unit's work. Work on projects is carried out by small teams assembled from both inside and outside Government. About half of the PIU's current project team staff are drawn from outside Whitehall, including from private sector consultancies, think tanks, NGOs, academia and local government.

Comprehensive information about other PIU projects can be found on the PIU's website at http://www.cabinet-office.gov.uk/innovation.

ANNEX B: THE PROJECT TEAM, SPONSOR MINISTER, ADVISORY GROUP AND WORKSHOPS

This report was prepared by a multi-disciplinary team, guided by a ministerial sponsor and an advisory group with Government and non-Government representation.

The Team

The team comprised:

Stephen Aldridge – chief economist, PIU

Sam Armstrong – on secondment from Environmental Resources Management (ERM) Ltd

Ian Coates – Government economist and (from 1 September 2001) joint team leader, PIU

Nicholas Eyre – on secondment from the Energy Saving Trust

Rob Gross – on secondment from Imperial College Centre for Energy Policy and Technology (ICCEPT)

Catriona Laing – team leader, on secondment from DFID

Catherine Mitchell – on secondment from Warwick Business School

William Nickerson – on secondment from Massachusetts Institute of Technology

Peter Ruback – on secondment from DTLR

Alison Sharp – permanent member of PIU

Shane Tomlinson – Government economist, PIU

The team was assisted by **Jake Chapman** – Open University, **Ian Christie** – Local Futures Group, **Stephen Glover** – on secondment from HM Treasury, **Sabrina Scott** – PIU, **Robin Smale** – OXERA Environmental Ltd and **Jenny Warson** – summer student. Additional expert input was provided by **David Pearce** – University College London, **Dennis Anderson** – ICCEPT and **Tim Foxon** – ICCEPT.

Sponsor Minister

The work of all PIU teams is overseen by a sponsor minister, in this case **Baroness Symons of Vernham Dean**, Minister for Trade, FCO/DTI.

Advisory Group

The team was greatly assisted by being able to draw on the experience and advice of its Advisory Group, although the report represents the views of the team and not of the Advisory Group. The team benefited from a process of consultation and review with the Advisory Group throughout the project. The group, chaired by Baroness Symons, comprised:

Richard Brown – HM Treasury

Andrew Burchell – Director of Environmental Protection Strategy Directorate, DEFRA

Tom Burke – Advisor to BP and RTZ

Ged Davis – Shell (Scenarios); (alternate, **Doug McKay**)

Brian Hackland – No 10 Policy Unit (alternate **David North**)

Peter Hewitt – Managing Director, Keighley Laboratories

Neil Hirst – Energy Policy Directorate, DTI

Sir John Houghton – Ex-head of Meteorological Office and UK Government Panel on Sustainable Development

Eddie Hyams – Chief Executive Officer, BizzEnergy Ltd

Professor Tim Jackson – Professor of Industrial Ecology, University of Surrey

Professor David King – Chief Scientist

Charlie Leadbeater – Research Associate, Demos

Nick Robins – Hendersons Investors

Dr Paul Rutter – Head of New Technologies, BP

Stephen Tindale – Director of Policy, Greenpeace

Ken Vowles – Executive Director – UK Power Operations, Scottish Power

Joanna Whittington – Director of Regulation & Financial Affairs, Ofgem

Workshop attendees

The team was also greatly assisted by being able to draw on the experience and advice of a number of experts who attended a series of seminars, workshops and panel discussions associated with the project. A full list of these events, and of the attendees, is available on request from the PIU.

ANNEX C: SUSTAINABLE DEVELOPMENT IN THE UK

The UK Sustainable Development Strategy

The UK Government's strategy for sustainable development[92] attempts to draw together economic, environmental and social policy. It has at its heart four key objectives:

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- prudent use of natural resources; and
- maintenance of high and stable levels of economic growth and employment.

Alongside these objectives, the strategy states that sustainable development will be achieved by setting policy in the context of ten key principles:

- Putting people at the centre – remembering that sustainable development is about giving people a better quality of life, now and in the future.
- Taking a long-term perspective – meeting today's needs while safeguarding the interests of future generations.
- Taking account of costs and benefits – including those that cannot easily be valued in money terms.
- Creating an open and supportive economic system – so that trade can flourish and competitiveness can act as a stimulus for growth and greater resource efficiency.
- Combating poverty and social exclusion – giving everyone the opportunity to fulfil their potential.
- Respecting environmental limits – recognising that some environmental problems impose limits that should not be breached.
- The precautionary principle – taking cost-effective action in the face of uncertainty, where there is a real risk of serious or irreversible damage.
- Using scientific knowledge – identifying sources of information of high calibre.
- Transparency, information and access to justice – available to all.
- Making the polluter pay – where possible, making those responsible for pollution pay for the costs imposed on society as a whole.

An overview of progress to date

The Sustainable Development Strategy envisages a future characterised by the sustainable prosperity that can be achieved through the pursuit of sustainable development. Progress in delivering sustainable development is to be measured against a series of quality of life indicators,[93] covering economic, social and environmental objectives. The Government's first Annual Report on progress suggests that

92 DETR (1999), op cit.
93 DETR (1999a), op cit.

a good start has been made, and some good foundations laid for the future. But there is a lot more to do, and some areas show cause for concern.

The UK Government measures sustainable development using 15 headline indicators and 147 core indicators at national level, in addition to regional and local indicators.[94] A full picture of the UK's performance can only be obtained by assessing trends in the full set of indicators, and any partial analysis should be read in this context. In addition – and as might be expected with the UK's Sustainable Development Strategy being only two years old – the indicators can only begin to tell the story of the UK's performance. But it is possible to pick out one or two key indicators relating to each of the economic, social and environmental objectives, and to use these to give an indication of how far the UK has come – and how much more it needs to achieve.

Economic issues

The Government's central objective is to achieve high and stable levels of growth and employment. Increasing the trend rate of growth over time is central to this objective, and by increasing productivity, the Government aims to raise the UK's trend growth rate.[95] This report picks out productivity improvements as a key economic objective, not only because of the direct links with resource productivity, but also because the progress made to date, and the size of the gap still to close, are reflective of the UK's performance against many of its objectives.

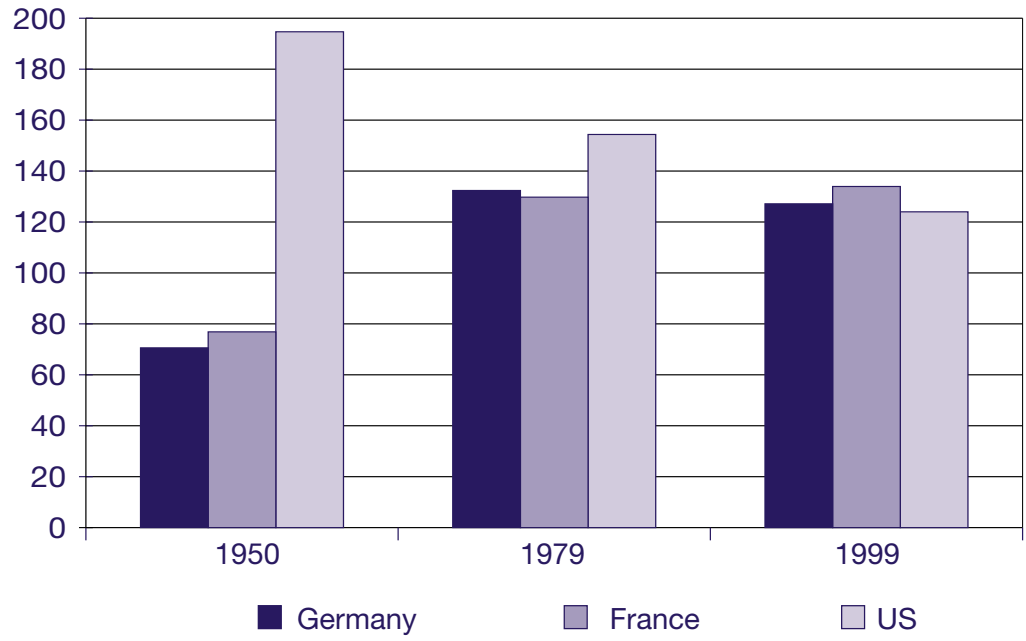
Poor productivity performance

There is considerable evidence to suggest that the UK's productivity performance is poor across the economy as a whole. This is why tackling the UK's productivity gap compared with its major competitors is at the heart of much of UK economic, industrial and education policy.

HM Treasury focuses its attention on labour productivity as the main indicator of the UK's productivity performance.[96] This can be measured using either gross domestic product (GDP) per worker, or GDP per hour worked. Under both measures, the UK performs poorly relative to its main competitors (Figure C1). The productivity gap versus the US has been in place since World War Two, and has closed to a significant extent over the last 50 years. In contrast, a productivity gap has opened up over the same period against France and Germany. However, a comparison of labour productivity in 1995 and 1999 suggests that the UK has outperformed France and Germany over the last few years.[97]

[94] Details available in DETR (1999a), op cit.
[95] HM Treasury, "Productivity in the UK: The Evidence and the Government's Approach" (2000a).
[96] Labour is typically identified as the most important factor of production that contributes to economic growth. The other main factors are capital and intermediate inputs, of which one component is natural resources. Economists focus on labour productivity because of its importance, and because it is intuitively appealing and easy to measure. Labour productivity is also a key determinant of per capita income. A detailed discussion of productivity is to be found in OECD, "OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity Growth" (2001).
[97] Crafts, N and O'Mahony, M, "A Perspective on UK Productivity Performance" (2001).

Figure C1: Real GDP per hour worked (UK = 100)[98]



Box C1: Total factor productivity

An alternative measure of productivity is total factor productivity (TFP) or multi-factor productivity (MFP). It shows the productivity of combined inputs used to generate gross output. TFP can help to disentangle the direct growth contributions of different factors of production. However, there are a number of problems with TFP. First, it is a residual left over after accounting for the contribution of labour and capital, so is often described as a "measure of what cannot be explained". Second, TFP requires a measurement of capital stock, which can often be problematic in terms of data availability and reliability. Perhaps because of these problems, measures of TFP have also fluctuated considerably from year to year. Notwithstanding these difficulties, the evidence available on TFP suggests that the UK's performance is similar to that measured using labour productivity.[99]

Various explanations have been put forward for the UK's poor productivity performance. These include skills shortages (particularly relative to Germany), lack of competitive pressures in some sectors and low levels of innovation and technological progress (particularly relative to the US), together with low levels of investment in physical capital in the UK. The UK has closed the investment gap to its competitors over the last 30 years, but capital per worker in the UK remains well below that in its main competitors.[100]

The Government's Productivity Strategy aims to raise productivity in the UK through the promotion of economic stability, and through "microeconomic reform" – targeted action to tackle market failures. Further details are

[98] Taken from Crafts N, Presentation to the IEA 16th State of the Economy Conference (2001).
[99] OECD, "The New Economy: Beyond the Hype", Final Report on the OECD Growth Project (2001b).
[100] HM Treasury (2000), op cit.

available in the Government's publications setting out its Productivity Strategy, published primarily alongside recent Budget and Pre-Budget Reports.[101]

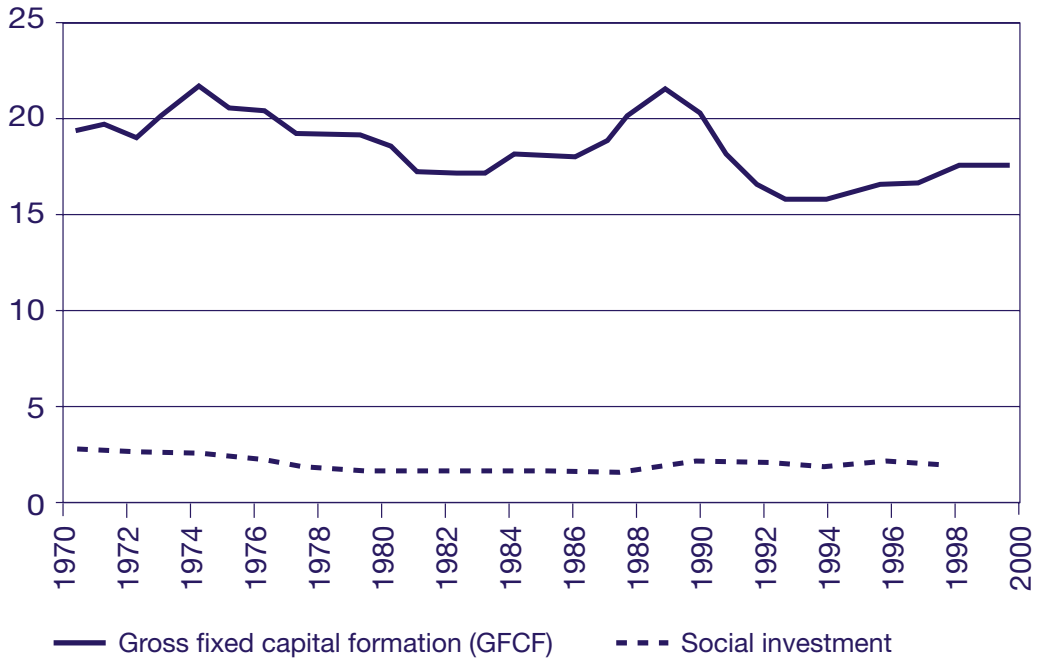
Levels of investment are an important indicator of long-term economic progress

Implications for productivity are one reason why levels of investment are one of the key economic indicators in the context of long-term sustainable development. The data show that over the most recent international economic cycle, UK investment performance has been extremely good in international terms.[102] However, social investment in assets such as railways, buses, hospitals, schools, water and sewerage appears to have been flat or slightly in decline (Figure C2), though this may partly reflect definitional problems.

Environmental issues

There are many environmental challenges facing the UK today, and the headline indicators include measures of greenhouse gas emissions, air quality, river water quality, road traffic levels, land use, waste arisings and wildlife populations. Among these indicators, arguably the most attention has been paid to the level of greenhouse gas emissions, in connection with international efforts to combat climate change.

Figure C2: Total investment and social investment as a percentage of GDP, 1970-2000[103]



[101] HM Treasury (2000), op cit; HM Treasury, "Productivity in the UK: Progress Towards a Productive Economy" (2001b); HM Treasury, "Productivity in the UK: Enterprise and the Productivity Challenge" (2001a).

[102] HMT (2001a), op cit.

[103] Data taken from http://www.sustainable-development.gov.uk/indicators/headline/h2.htm. Firm estimates of social investment are not available for 1993 and following years. Investments by asset type have become much more difficult to estimate as a result of the Private Finance Initiative (PFI), the privatisation of industries such as rail, buses, water and sewerage and as a result of mixed investment by large companies.

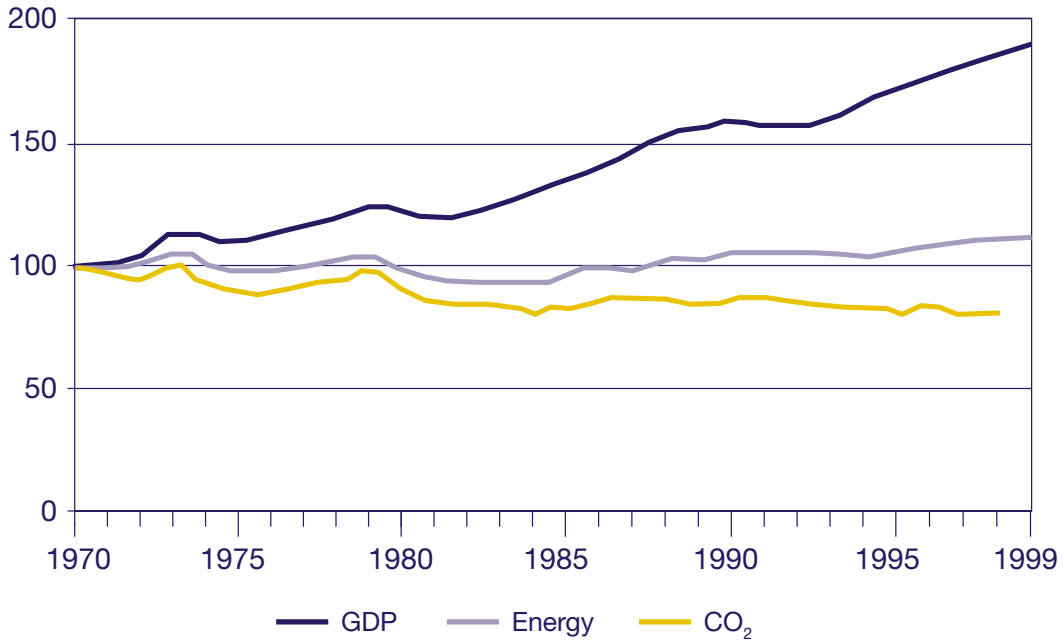
Greenhouse gases contribute to the greenhouse effect, which in turn is predicted to contribute to unacceptable levels of global warming – in terms of the likely impacts on the world's economies, societies and natural habitats – if global emissions continue at their current rate.[104] The UK is one of only a few OECD countries estimated to have met the internationally agreed aim of reducing emissions to 1990 levels by 2000, and is on track to meet its emissions reduction target under the Kyoto Protocol.

The UK has gone a long way towards decoupling emissions from economic growth

The UK has also had considerable success in decoupling greenhouse gas emissions from economic growth (Figure C3). Over the last 30 years, while GDP has almost doubled, energy use has remained relatively static and emissions of carbon dioxide – the main greenhouse gas – have fallen by around 20%.

The significance of this achievement should not be under-estimated, but nor should the challenge in terms of how much more is likely to be needed. Future targets will require further emission reductions. A significant proportion of those achieved to date have come from one-off structural changes, such as shifts in the composition of the economy and increasing electricity generation from gas and nuclear, at the expense of coal. This is why the Government has instigated a Climate Change Programme, which aims to continue the decoupling into the future.[106]

Figure C3: GDP, energy use and carbon dioxide emissions – trends since 1970 (1970 = 100)[105]



[104] See, for example, Section One, Chapter One in DETR (2000b), op cit.
[105] DETR (2000b), op cit.
[106] DETR (2000b), op cit.

Social issues

Although not the focus of this report, it is important to note that sustainable development cannot be achieved without tackling social problems. The Sustainable Development Strategy's indicators show that the benefits of economic growth have not been shared equally by everyone.[107] For example:

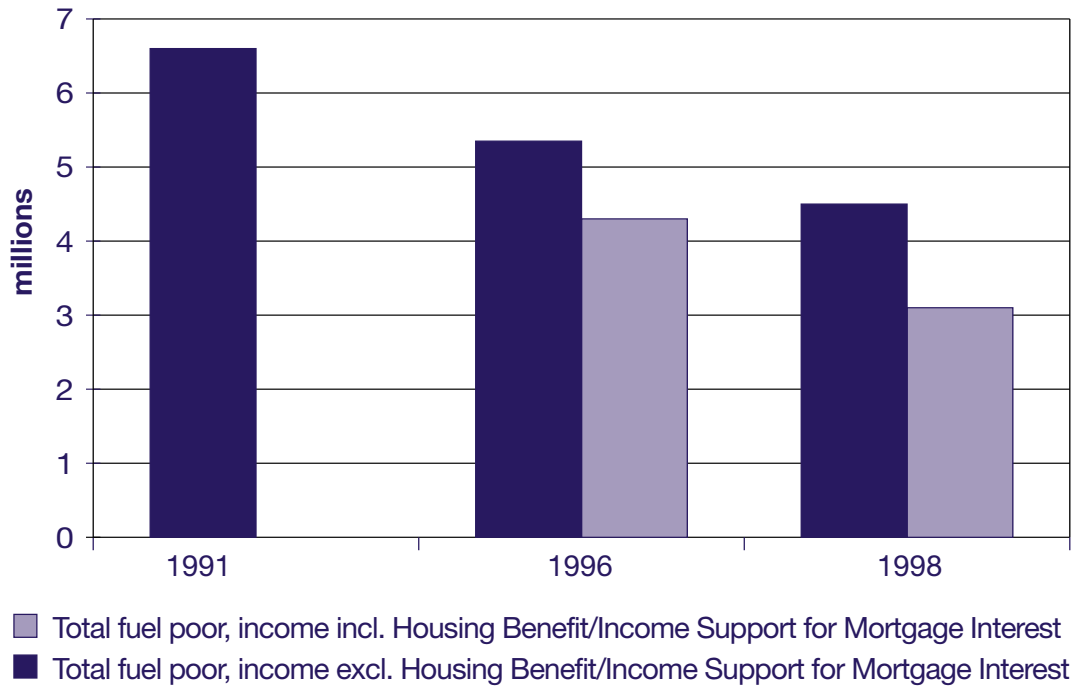
- in 2000, 16% of working age people had no qualifications;
- in 2000, 12% lived in workless households;
- in 1994, 17% of children lived in households with persistently low incomes; and
- in 1998, over a third of single over-60s in England experienced fuel poverty.

Government set in train a strategy to tackle these problems in 1999, with the publication of its document "Opportunity for All".[108] It set out a new approach that would aim to tackle the causes of poverty and social exclusion, as well as the problems themselves.

Fuel poverty

One social indicator that has shown some improvement is the overall level of fuel poverty in the economy (Figure C4). These improvements can be linked to the range of Government initiatives such as the winter warmer payments, now standing at £200 per annum, and the Home Energy Efficiency Scheme, which targets energy conservation measures at vulnerable households.

Figure C4: Households in fuel poverty in England, 1991, 1996 and 1998[109]



[107] DETR (1999a), op cit.
[108] DSS, "Opportunity for All – Tackling Poverty and Social Exclusion – First Annual Report 1999", CM 4445 (1999).
[109] Taken from http://www.dti.gov.uk/energy/pdf/fuel_pov.pdf.

Households are defined as fuel poor if they need to spend more than 10% of their income to keep warm. The Government's first priority – set out in its Draft Fuel Poverty Strategy[110] – is to ensure that by 2010, no older householder, no family with children and no householder who is disabled or has long-term illness need risk ill health due to a cold home. These householders are particularly vulnerable to the health consequences of fuel poverty. In 1999 there were estimated to be about 3 million such households, about 70% of the fuel poor in the UK. Once progress has been made on the priority vulnerable groups, the focus will be widened to include those healthy adult householders in fuel poverty.

Resource use and environmental pollution more generally can also have an adverse impact on human health. For example, respiratory diseases can be exacerbated by local air pollution, and evidence suggests that air pollution can cause breathing difficulties, particularly among people who are already asthmatic. Moreover, current evidence suggests the prevalence of asthma is now at its highest level for several years, though this may be due, in part, to greater awareness of the extent of an existing problem.

More generally, the links between social and environmental concerns are poorly understood. The Joseph Rowntree Foundation published a report in 1999 that highlighted some key areas where a better understanding of the interactions is needed.[111] Following up on that report and the subsequent research will be important if sustainable development is to be placed centre-stage in the UK, but is beyond the scope of this report. One important area on which findings have been published recently concerns the environmental concerns of disadvantaged groups.[112] This is discussed in section 4.2.5.

[110] DETR, "The UK Fuel Poverty Strategy – A Consultation Paper" (2001).
[111] Voisey, H and Hewett, C, "Reconciling Social and Environmental Concerns", Overview paper for the Joseph Rowntree Foundation RESC Research Programme (1999).
[112] Burningham et al (2001), op cit.

ANNEX D: SUSTAINABLE DEVELOPMENT IN THE REGIONS

Within the UK, many of the policies and responsibilities that will affect resource productivity have been, at least in part, devolved to sub-national bodies. The devolved administrations in Scotland, Wales and Northern Ireland are beyond the scope of this report, and local authorities have been considered only in relation to waste management. But this case study focuses on the role of the English regional bodies.

A regional aspect to resource productivity?

It might be argued that a framework for resource productivity improvements should be set by national Government, and delivered by company and household decisions. In that case, the role for regional Government in delivering resource productivity improvements would seem to be very limited.

But this severely underplays the regional aspect to resource productivity. The Government's quality of life indicators include regional indicators. And the Sustainable Development Strategy instigated regional sustainable development frameworks for each English region.[113] Many issues highlighted by the resource productivity framework have a clear regional dimension. For example:

- Although not corresponding to the English regions directly, water catchment and abstraction areas are regional in nature.
- A relatively small proportion of waste from a local authority is processed (landfilled, incinerated or recycled) within that local authority. But equally, waste is not transported from one end of the country to another. Instead, with the exception of large volumes of waste taken outside London, waste is moved about primarily within regional boundaries.

Table D1: Percentage of industrial and commercial waste retained within regions

Origin of waste	Percentage of waste retained within that region
East Midlands	74%
East of England	83%
London	16%
North East	87%
North West	92%
South East	83%
South West	83%
Wales	84%
West Midlands	84%
Yorkshire and the Humber	94%

- A large amount of surface transport takes place within regions. This implies a role for regional Government in tackling the causes and problems of congestion, through innovations in spatial planning.

[113] Paragraph 7.81 of DETR (1999), op cit.

Box D1: Regional Government in the UK

The RDAs aim to co-ordinate regional economic development and regeneration, enabling the regions to improve their relative competitiveness, and to reduce the imbalances within and between regions.

Regional Development Agencies: England (MSU 07/99)

- Each of the English regions has its own resources of particular importance. These range from national parks to coal mines, from quarries to coastlines.
- The regional level may be the most appropriate at which to consider issues such as cluster formation, which transcend local authority boundaries, yet are clearly sub-national.

The regions and resource productivity

Power and responsibility at the regional level are divided between a number of different bodies. Most significant are the Regional Development Agencies (RDAs), the Regional Assemblies, the regional Government Offices (GOs) and regional Local Government Associations (LGAs). Others include the Regional Observatories (for statistical research and analysis) and regional Sustainable Development Roundtables.

Each of the key regional bodies has responsibility for one or more policy documents with an impact on resource productivity within the region. For example, the RDA produces a Regional Strategy, the regional LGA or Regional Assembly produces Regional Planning Guidance (RPG) and the Regional Assembly produces a sustainable development strategy.

At face value, this resembles the same piecemeal approach associated in the past with successive national Governments. With separate bodies responsible for agendas that are inextricably linked, there is a risk that policy-making will not be joined up, that common goals will not be pursued and that mixed messages could be sent. Some have argued that the latest reorganisation of departments in Whitehall will reinforce the potential for fragmentation, by splitting responsibility for Government Offices, regional chambers and RDAs respectively between the Cabinet Office, DTLR and DTI.

Box D2: Sustainable development in the East Midlands

At least one region has attempted to put sustainable development at the heart of all its policy-making. The East Midlands Regional Assembly has worked directly with the East Midlands Development Agency (EMDA) and the Government Office in developing an Integrated Regional Strategy (IRS).[114] The East Midlands was the first region to incorporate its IRS and regional sustainable development framework into the same document. It is based on the four themes of economic, environmental, social and spatial issues. The purpose of the IRS has been to achieve integrated regional policy-making to deliver a sustainable East Midlands.

Even though the document was published as recently as December 2000, it has already succeeded in securing compatibility between the East Midlands Regional Strategy and RPG, in the context of delivering sustainable development. The IRS is being taken forward by the East Midlands LGA and Regional Assembly, supported by the Government Office, Development Agency and other regional/local partners. A sustainable development action plan is in place, including work on awareness, education and climate change. Working groups have been set up to take forward other issues, and part of their role is to spread best practice.

[114] East Midlands Regional Assembly, "England's East Midlands Integrated Regional Strategy – Our Sustainable Development Framework" (2000).

However, there is some evidence to suggest that regions can avoid this trap. Each Regional Assembly has a responsibility (and funding) to scrutinise its RDA on its commitment to sustainable development. It is too early to estimate how effective this will be in practice, though there must be some concerns about the impact of this scrutiny. At present, the only way in which an Assembly can sanction an RDA is through representations to the Secretary of State.

Even with this scrutiny, there is a risk that sustainable development will remain a theme alongside the Regional Strategy and RPG – its effective status in the policy hierarchy – rather than as the overarching objective.

Resource productivity initiatives and partnerships in the North West

The North West region has established a wide range of projects and partnerships to further sustainable development. The region has a complex network of institutions engaged in the agenda: the Regional Development Agency (NWDA), the Government Office (GONW), the Regional Assembly (NWRA), and multi-sector partnerships such as the NW Climate Group, formed to consider the impacts of climate change. Other partnership bodies include Sustainability NorthWest (SNW), which facilitates much partnership work in the region.

The region has a framework for sustainable development, Action for Sustainability (AFS), initiated by GONW and concluded by NWRA, with secondees from GONW and the Environment Agency. Development of AFS is managed by NWRA and overseen by its Sustainability Steering Group. AFS has been formally adopted by the Regional Assembly.

AFS includes goals for resource productivity and renewable energy. In the absence of good regional information for setting targets, national targets were allocated. In addition, waste and energy were highlighted in the recent review of RPG and renewables and energy efficiency were highlighted in the Regional Strategy. Since the publication of AFS in 2000, a preliminary renewable energy study has been completed and a draft regional waste strategy is to be published.

The renewables study was directed by a sub-group of the NW Climate Group (which has already published a preliminary study on the potential impacts of climate change on the region – the first regional study to be carried out in Europe). The next step in relation to renewables is a bid for funding of the appointment of a "champion" in the region to take forward the study's recommendations, such as the development of a renewables partnership for the North West.

On waste, the region starts from a low base in recycling and recovery. There are also problems in linking the regional level to the county and unitary local authorities, and considerable political inhibitions in relation to incineration and the costs of segregating waste for recycling and recovery. Waste issues require extensive processes for public debate, and more attention to the problem of lack of markets for some recycled goods. The NWRA has led the process of responding through a regional waste strategy, working with partner organisations and developing scenarios for change. Waste is a key issue, as there are only some five years of landfill capacity remaining and just 8% of the region's waste was recycled in some form in 1998. Other resource efficiency projects include the Cleaner Merseyside initiative, one of a number of independent one-off schemes.

The North West region's achievements

Diverse stakeholders in the North West's programme for sustainable development agree that the region has established many effective partnerships, and has succeeded in pushing issues such as climate change, waste minimisation and renewable energy up the agenda of the key regional actors. There is also agreement that considerable progress has been made in building up capacity for effective debate between many different sectoral interests, although more remains to be done to overcome barriers.

The region is seen by stakeholders in AFS and other initiatives as a pioneer in seeking to integrate sustainable development and resource efficiency issues into the heart of regional planning – although much more needs to be done before this is accomplished. The NW Climate Group has been effective in stimulating awareness of the impacts of climate change and has worked with GONW, SNW and others to produce a pioneering regional inventory of greenhouse emissions.

AFS includes an action plan, SAVE, which sets out key resource productivity and conservation targets. The targets are for: cutting greenhouse emissions; increasing use of demand management and new technologies to reduce energy and water consumption; increasing the proportion of energy generated from sustainable and renewable sources; minimising the production of waste and increasing recycling and recovery rates (including the goal of 40% recovery of municipal waste and 25% recycling/composting of household waste by 2005).

AFS also has a pivotal role in appraisal and scrutiny of key regional strategic documents. AFS has already had a central role in the sustainability appraisals of both the NWDA's Regional Strategy and draft Regional Planning Guidance (RPG). It has been used to inform the development of the region's European Structural Fund Programmes and in the sustainability appraisal of all Single Regeneration Budget applications. It has also been used to appraise the draft regional waste strategy, a number of development plans and, in a pilot study, a raft of Local Agenda 21 plans. Formal guidance on appraisal is to be produced by the Regional Assembly building on best practice identified from the development of AFS. It is hoped that this will be adopted for sustainability appraisals of Community Strategies by local authorities/Local Strategic Partnerships and in the appraisal of Local Transport Plans.

Other innovative work done in the region includes the Manchester 2020 study, a major research project to model the flow of resources in the so-called urban metabolism of the city and its region; and SNW's Timeline Project, a study which included the creation of a CD setting out sustainability visions to 2050.

Problems to be overcome

Overall, the region has made impressive progress in developing capacity for partnership work and long-range thinking on resource productivity and renewables. The key to faster progress seems to be greater clarity in the national framework for regional governance and planning, which should make coordination and joined-up action easier to achieve for all regions, not just the North West.

There seems to be general agreement that the key barrier to faster progress in the regions is the complexity of regional

institutions and partnerships, and of the multiple processes for regional planning. These are seen as still poorly co-ordinated across all the regions and are felt to make joined-up action for sustainable development hard to achieve. In the North West, the AFS framework is not yet a true strategy, as it needs to be integrated with the Regional Strategy and other core plans. Thus policy on renewables and resource productivity has yet to be converted into integral elements of a coherent Regional Strategy, owned by all the major actors, and fully resourced to take forward the work already done.

There are information shortfalls that affect strategic analysis and planning: for example, waste arisings data are unreliable and insufficient, and more information is needed about supply and demand in relation to skills for advancing resource productivity and renewables.

Looking to the future

The approaches taken by the East Midlands and by the North West act as an example not only at regional level, but at national level also. For example, by putting sustainable development at the top of the hierarchy and at the heart of policy-making, the East Midlands has put in place a framework that could help to deliver a resource productive region over the coming years.

But there is still room for improvement. While the IRS remains a voluntary initiative, it depends entirely on the goodwill and vision of the various regional bodies in delivering its benefits. And in the North West, there is concern that poorly joined-up agendas and organisations hinder integration of sustainable development into the regeneration work of the RDA and the key players in the regional economy. So there are big question marks surrounding the ability of the regions to carry through on the sustainable development agenda, given their limited powers. One initiative that will undoubtedly help is the change in funding arrangements that will give the RDAs freedom in how they spend their budgets from April 2002, subject only to delivering on their statutory objectives.

Sustainable development needs to be placed formally and explicitly at the centre of regional responsibilities, just as it should be placed at the centre of national policy-making. There is a need for analysis to identify those areas where regional bodies can add value in securing greater resource productivity and sustainable development.

ANNEX E: THE SPECIAL CASE FOR SMALL BUSINESS

Despite the barriers, many UK companies have made great strides in improving the productivity and efficiency with which they use resources, and in reducing the levels of waste and pollution for which they are responsible. But a great opportunity remains in tackling the resource productivity and efficiency of small businesses.

For example, estimates from the Energy Saving Trust (EST) show a cost-effective potential energy saving of 22% on total 1999 energy use among companies employing 20 or fewer employees.[115] This would amount to a total energy cost saving of almost £500 million per annum.

The existence of this potential is cause for a twofold concern. First, it means that companies are failing to exploit opportunities to reduce their day-to-day costs. Second, it means that easy opportunities to reduce environmental damage are being missed, putting more of an onus on other parts of the economy and on more expensive measures.

It is important not to generalise. Some small businesses work in energy intensive sectors, or are part of energy intensive supply chains, and they are likely to have taken steps to make more productive use of energy and to cut down on wastage. But they are likely to be the exception rather than the rule.

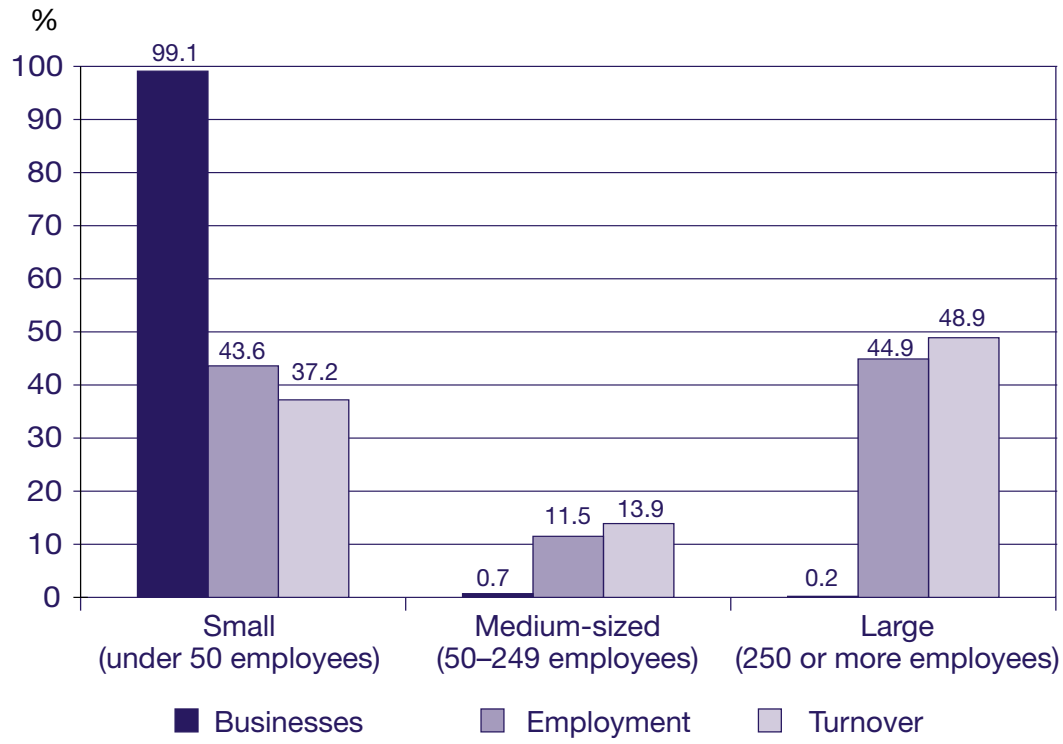
There are many explanations for the relatively poor resource productivity performance among small businesses as a whole. But two key factors stand out:

- Small businesses are much more likely to face constraints of management time, capital and information. Their priorities are more likely to be in the short term than the long term. And they are also likely to be tenants rather than owners of their own accommodation. All of these factors make take-up of resource productivity measures less likely.
- The focus of Government policy measures to date has been on larger companies, where action to reduce pollution, improve energy efficiency and cut down on waste is likely to deliver better value for money and bigger savings.

Government's approach has been perfectly reasonable in the context of making effective use of taxpayers' money. But there are many dangers in ignoring small businesses. Not the least of these is the sheer size of the small business sector. Information gathered by the Small Business Service (SBS) shows that small businesses account for 99% of all business in the UK by number, employing somewhat less than half of all employees, and accounting for more than a third of total turnover (Figure E1). In addition, small businesses are particularly prevalent in many of the fast-growing service sectors.

[115] Cost-effectiveness estimates are based on net present value calculations for a range of specific energy conservation measures across a range of non-domestic building types. An 8% discount rate was used.

Figure E1: Share of private sector businesses, employment and turnover by size of business, UK



With the UK facing increasing pressures in reconciling its economic, social and environmental agendas, the time is ripe for attention to be turned to the opportunities presented by small businesses. Analysis carried out by the EST shows that it is among the smallest companies (fewer than 20 employees) that there is the opportunity to make the greatest percentage reduction in energy use through cost-effective energy measures.[116]

A focused approach to sustainable development for small businesses

Because small businesses have a number of unique characteristics not shared by larger companies, the type of approach used successfully for these larger companies is unlikely to be effective when small businesses are the target. Instead there is a case for creating a focused and coherent approach to sustainable development for small businesses, based around improvements in resource productivity which will benefit small businesses as well as contributing to sustainable development goals. The approach should be developed by DEFRA and DTI in conjunction with the SBS and with the small business community. It should be informed by the conclusions on energy efficiency emerging from the Government's review of energy policy. And it should build on the analysis carried out by EST, which showed that small and medium-sized enterprises (SMEs) are systematically missing out on energy and environmental advice from most sources.

[116] EST (2001), op cit.

The approach should be developed along the lines of the following broad themes:

- High-level regulatory and fiscal instruments alone are unlikely to provide a significant impetus for behavioural change at all times. Small businesses typically have neither the information, the time nor the capital – and sometimes not even the responsibility, where they are tenants in rented accommodation – to respond to high-level signals. Small businesses will typically be affected disproportionately by each of the first four key barriers – prioritisation among limited resources, information deficiencies, limited access to capital and contractual inadequacies – identified in Chapter 1. This does not mean that these types of measure should be avoided, but it does mean that they should be accompanied by specific measures to assist small businesses in making an appropriate response.
- Provision of information and advice to small businesses should be concise and tightly focused. Small businesses will not have the time or the personnel to read through large numbers of leaflets, or to contact many different organisations. As far as possible, relevant information should be co-ordinated by one organisation, and "one-stop-shop" approaches adopted.
- Those organisations that provide advice to small businesses should also consider taking responsibility for carrying out any necessary installations and activities to improve resource productivity. This would be consistent with the concept of the "service provider" or "enabler". To provide objectivity, a national benchmarking scheme would enable comparisons, inform recommendations and assist dissemination.
- The national level is often too remote to be relevant to small businesses. This suggests a role for regional or local bodies. Regional Development Agencies (RDAs) and Regional Assemblies can play a role, and at a more local level, Chambers of Commerce. To be effective, a coherent strategy must be developed, which rationalises the role that each organisation plays. There is also a strong case for reviewing the outcomes expected from Business Link networks, with a view to specifying responsibilities across the full range of sustainable development objectives.
- Small businesses often pay low rates of corporation tax, or are not subject to corporation tax at all. This makes it difficult to provide tax breaks for resource productivity investment. Alternative solutions should be explored, including providing the incentives to intermediaries (such as landlords or energy service providers), or fast-tracking the route to project-based credits in emissions trading schemes.

ANNEX F: THEORETICAL UNDERPINNINGS

Summary

- Since industry took over from agriculture as the main sector of western economies, natural resources and resource productivity have played little role in theories of economic growth and models of the production function.
- One reason for paying more attention to natural resources is the scarcity of resource inputs – economies cannot continue to rely indefinitely on the depletion of non-renewable resources. But more pressing are concerns about the depletion of pollution sinks, and associated environmental problems.
- Economists use production functions to model the production process and to help explain economic growth. Neoclassical models attributed long-run growth to unexplained technological change. Growth accounting tries to identify different contributions to economic growth. Endogenous growth theory tries to explain technological change.
- These models generally exclude natural resources and hence resource productivity. But resource productivity has a direct impact on the production process and on economic growth through impacts on capital stocks, and through impacts on costs in resource-intensive industries. At the same time, improvements in resource productivity can be crucial in easing environmental constraints and delivering greater welfare.
- The impact of natural resources can be included in neoclassical and endogenous growth models. Empirical evidence suggests that the costs of avoiding resource depletion can be significant, but is less well established on the damage effects of resource depletion and the wider benefits to action to avoid resource depletion.
- These results are consistent with some endogenous growth models in which long-term growth can be affected by environmental policy, and under certain circumstances that impact may be positive.

Introduction

Economists model the productive capacity of an economy using a production function. What this shows is the way in which different inputs come together to form outputs. The aggregate level of output is typically shown to depend on two key determinants:

- the quantity used of each factor; and
- the productivity with which each factor is used.

The components of the production function have evolved over time. The main focus of this evolution has been the changing role and importance of different factors of production. In very broad terms, this evolution has taken the following path:[117]

- In the formative days of modern economics, in the early mid-18th century,

[117] Bleischwitz, R, "Rethinking Productivity: Why has Productivity Focused on Labour Instead of Natural Resources", Environmental and Resource Economics (2000) provides a more comprehensive history of the evolution of the production function, on which this summary is largely based.

agriculture was the dominant activity in much of the Western world. This meant that land and natural resources were identified as the most important inputs to the production process, and ownership of land was generally taken to be the main source of wealth.

- By the late 18th century, Western world economies – particularly the UK – were beginning to see the real emergence of the industrial revolution, and a shift from an economy based around agriculture to one based around industry. So when Adam Smith wrote his *Inquiry into the Nature and Causes of the Wealth of Nations*[118] in 1776, he identified the use of labour in industry and trade as the main source of national wealth. However, he continued to recognise the importance of natural resources in allowing replenishment and growth in the capital stock, facilitated by the productive use of labour. The economic growth of that period was hence based largely on the cyclical development of a physical capital stock, using the previous vintage of capital and, crucially, natural resources such as water and coal.
- After Smith, economists focused more and more attention on the productive use of labour in delivering output and growth. This reflected the ongoing changes in the economy, which increasingly saw mass production manufacturing based around labour and capital. The reduced importance of agriculture and improvements in yields per hectare of land meant that land was no longer seen as a scarce resource. And natural resources such as coal and water were in plentiful supply.
- In 1956, Robert Solow pioneered the so-called neoclassical theories of growth, based upon the productive use of both labour and capital. These theories took technological change as something determined outside of the production function, but more recent endogenous growth theories have explained technological change within the parameters of the production function. These theories have also recognised the increasing role of the service sector, by giving a major role to human capital (knowledge and skills).

The result of this evolution has been that land and natural resources have become less and less important in explanations of productivity and economic growth. But one of the more recent evolutions in the production function literature has begun to reverse this trend. Increased awareness of and focus on environmental issues has led to a number of attempts to model explicitly the interactions between the economy and the environment in the context of the production function. The purpose of this annex is to present very briefly the main highlights of this new literature, and to assess the implications for policy.

Theories of economic growth

Neoclassical theories

The Solow[119] model of 1956 was the first of the neoclassical models of economic growth, and formed the basis for all subsequent developments of the neoclassical framework over the next few decades. The Solow model sees output (Y) determined by capital (K), labour (L) and "knowledge" or the "effectiveness of labour" (A). These three inputs combine to produce output in any given year (t).[120]

$$Y_{(t)} = F\,(K_{(t)},\ A_{(t)},\ L_{(t)})$$

[118] Smith, A, "An Inquiry into the Nature and Causes of the Wealth of Nations", first published 1776, reprinted by Clarendon Press (1976).
[119] Sometimes referred to as the Solow-Swan model, reflecting the contribution made by TW Swan in his paper of the same year.
[120] Romer, D, "Advanced Macroeconomics", McGraw Hill (1998).

The key features of the model are that:

- The only way for output to increase over time is through an increase in the amount of labour and capital; or through an improvement in technology that enables more output to be derived from the same quantities of capital and labour through an increase in knowledge.
- Knowledge and labour enter the equation multiplicatively, such that knowledge (and hence technology) is assumed to be labour-augmenting.

A number of different specifications of the model have been formulated, most notably the Cobb-Douglas form that exhibits constant returns to scale,[121] is easy to use and has been robust in many empirical analyses. But all of the functional forms based on the Solow model have a major drawback with regard to the way in which they explain economic growth in the long term. Once volumes of capital and labour have settled down to a steady state, the only explanation of economic growth is technological change, which is an exogenous variable in the model.

Growth accounting

An early response to the limitations of the Solow model was the development of growth accounting. This was pioneered in the 1950s, and was an attempt to try to explain short-run economic growth, and to make an assessment of the long-run impacts on growth of structural changes (for example shifts in the sectors of the economy) and of education. The previous section noted that economic growth could be due either to labour or capital accumulation, or to technological change. Similarly, output per worker (labour productivity) could grow only as a result of capital accumulation or technological change. Growth accounting attempts to determine the relative contribution of each.

Endogenous growth theory

Endogenous growth theories have been developed largely in response to the drawback in neoclassical models. Empirical analysis has shown that the role of technological change is crucial in driving forward the productive use of factor inputs, so it is important that policy-makers try to understand how technological change occurs. The main feature of endogenous growth models is that technological progress is explained within the model.

The first exposition of endogenous growth theory was put forward by Paul Romer in 1986.[122] The theory draws heavily on lessons from microeconomics, in attributing economic growth to improvements in productivity through means such as r&d, education and spillover of positive externalities. The key strength of endogenous growth theory is that economic growth is explained within models. The major drawback is that the models have proven difficult to test empirically, with standard regression techniques often invalid.

Box F1 sets out one formulation that captures the essence of endogenous growth models.[123] A key conclusion relates to the importance of investment and innovation. Innovation is crucial in determining economic growth – and because there are externalities associated with r&d, there is justification for Government intervention to bring the rate of innovation (and hence of growth) up to its optimal level (see section 4.2.3). The externalities typically associated with r&d are:[124]

[121] That is, a doubling of the quantities of both inputs will lead to a doubling of output.
[122] Fine, Professor B, "Endogenous Growth Theory: A Critical Assessment", SOAS Working Paper Number 80 (1997).
[123] Pearce, D, "Resource Productivity: An Outsider's View of the State of Play and What Might Need to be Done", UCL (2001).
[124] Romer (1998), op cit.

- *The consumer-surplus effect.* In competitive markets, innovators cannot procure all of the surplus from innovation as monopoly rents – some of it will be passed on to the consumers of innovation (those who license the innovation in order to produce goods).
- *The inter-temporal spillover effect.* Even if a patent is issued for a new innovation, the knowledge associated with that innovation can generally be used by other innovators in the future.

Box F1: The essence of endogenous growth models

Removing the (t) subscripts for notational simplicity, and adopting a Cobb-Douglas functional form, a simple production function could be written as:

$$Y = T.K^{\alpha}.L^{1-\alpha} \qquad (1)$$

where T is total factor productivity, and technological change (A) is embodied in capital and labour.

Dividing through by L gives:

$$\frac{Y}{L} = T.\left(\frac{K}{L}\right)^{\alpha} \qquad (2)$$

or:

$$y = T.k^{\alpha} \qquad (3)$$

Taking logarithms and letting $\alpha = 1 - ß$:

$$\ln y = \ln T + (1 - ß) \ln k \qquad (4)$$

where ß is simply the share of labour in the economy.

Let technological change be embodied in the form:

$$\ln A = \gamma \ln k \qquad (5)$$

so that:

$$\ln y = \ln T + (1 - ß + \gamma) \ln k \qquad (6)$$

Equation (6) includes TFP as a residual after accounting for embodied technological change. Innovation will raise the capital–labour ratio, raising output by 1– ß plus the additional spillover effect shown by γ.

Incorporating resources and the environment into growth models

Resource productivity and sustainable development

Concerns about resource scarcity in the early 1970s saw an increased interest in the role of natural resources in the economy. Because of its roots in these concerns, the literature of the 1970s[125] focused its attention on the possible constraints imposed by non-renewable resource inputs on economic growth. The literature concluded that if production is dependent on a non-renewable resource, then if the average productivity of that resource is bounded above, there is a finite limit to cumulative production, and no positive level of production and consumption can be sustained indefinitely. Technological progress and substitution of capital for resources can both increase the average productivity of the resource. And of course, it may be possible to reduce or even remove production's dependence on the non-renewable resource. For example, if resources such as oil, coal and natural gas are finite, then ultimately we might envisage that the economy will need to rely on renewable forms of energy.

But with the (not insignificant) exception of this literature, the role of these resources (including pollution sinks and the wider environment) has until recently been off the growth economist's agenda since the shift from agriculture to industry in western economies. The reason for the new literature incorporating resources and the environment is not the traditional concern about resource input scarcity. Rather, the new literature derives from what is currently a more pressing concern about environmental damage and depletion of pollution sinks.

The main report has noted that while improvements in resource productivity are certainly not a sufficient condition for the achievement of sustainable development, it is difficult to see sustainable development being achieved without improvements in resource productivity – and they have certainly been placed at the heart of the UK's Sustainable Development Strategy.[126]

The economists' definition of sustainable development states that the sum of all capital assets – human, physical, social and environmental – must be constant or rising over time on a per capita basis, so that successive generations enjoy constant or increasing levels of wealth.[127] This is in direct contrast to, for example, the conclusions derived from the Cobb-Douglas formulation of the neoclassical production function, which are that sustained positive wealth and consumption are optimal only when the social rate of time preference is zero.[128]

In this context, the role of resource productivity is manifold. Some key issues are assessed in more detail overleaf, particularly in relation to issues relating to the role of natural resources in the production function. But examples of the role of resource productivity in sustainable development include the following:[129]

- If resource availability imposes a genuine "limit" to economic activity (for example, the ability of the atmosphere to absorb the

[125] The literature was pioneered by the likes of Joseph Stiglitz, Partha Dasgupta and Geoffrey Heal, all of whom contributed to the Review of Economic Studies Symposium on the Economics of Exhaustible Resources in 1974. A full summary of the key conclusions is presented in Section 6 of Krautkraemer, JA, "Nonrenewable Resource Scarcity", Journal of Economic Literature, Volume XXXVI (1998).
[126] DETR (1999), op cit.
[127] This is typically referred to as the Hartwick rule (Krautkraemer (1998), op cit.).
[128] Krautkraemer (1998), op cit.
[129] See Pearce (2001), op cit, and Smulders, S, "Economic Growth and Environmental Quality", in *Principles of Environmental and Resource Economics*, Edward Elgar (2000).

greenhouse gases arising from economic activity), then improvements in resource productivity will make that constraint less binding.

- For resource-intensive economic activity, improvements in resource productivity will lower production costs and increase labour productivity (subject to the possible negative impacts outlined below).
- Resource productivity improvements will contribute positively to improvements in environmental capital. The direct effect will be through more effective use of natural resources, such that economic growth requires less exploitation of natural resources. The indirect effect is less certain, and will be through slower environmental degradation, which itself can reduce the "quality" of environmental capital. (For example, there is evidence that ozone damages crops, while NOx may increase yields. Similarly, saline intrusion from rising sea levels as a result of global warming will damage crops, but other aspects of global warming can improve yields.)[130]
- There is also evidence to suggest that pollution and environmental degradation can have an adverse impact on human and physical capital. Capital assets can be widely damaged by these impacts, requiring appreciable expenditures in restoration or replacement. And there is comprehensive evidence on, for example, the impacts of air pollution on human health, which is itself a determinant of labour productivity.
- Finally, it is important to recognise that the usual measures of output do not measure well being, because they ignore non-market values. Improvements in resource productivity will have a much greater beneficial impact on true well being than shows up in production functions.

Natural resources in the production function

The first step to incorporating these issues in models of economic growth is to rewrite the production function so that it includes natural resources. The following functional form is based on that in Box F1, but generalises from the Cobb-Douglas form and includes natural resources (R):[131]

$$Y = T.K^{\alpha}L^{\beta}R^{\kappa}$$

so that taking partial differentials[132] and denoting growth rates by "r":

$$r_y = r_T + \alpha.r_K + \beta.r_L + \kappa.r_R$$

The coefficient κ represents the share of natural resources in the national accounts – and as explained in the main report, this is lower than it should be due to the under-valuation of non-market impacts. But in addition, this formulation fails to incorporate a number of effects:

- The formulation ignores the effect of environmental damage on all of the factors of production, and on technological progress (which is dependent on the other factors). If "d" is taken to represent the overall effect of environmental damage per unit of output, then we obtain:

$$r_y = (r_T + \alpha.r_K + \beta.r_L + \kappa.r_R).(1 - d.Y)$$

[130] These impacts are subject to the size of the "rebound" effect. Improvements in resource productivity will make natural resources more attractive as factors of production. This could induce some switching away from other factors towards resource inputs. The net impact on resource use and on the environment will then be determined by the relative impacts of the efficiency improvement and the switching of factors. Evidence from energy efficiency suggests that the rebound effect rarely (if ever) outweighs the effect of the initial improvement.

[131] Based on Anderson, D, "Resource Productivity: A Comment", Imperial College (2001).

[132] The inter-dependence between variables means that strictly speaking, it is not valid to take partial differentials. But this is ignored in this exercise, for the purposes of simplicity.

such that if damage rises in line with output, and if nothing is done about it, growth will slow down and could be brought to a halt. In practice, this will almost certainly not happen. The "environmental Kuznetz curve" suggests that levels of environmental degradation eventually decline as economies grow. Indeed, at the aggregate level, the value of "d" in the UK would appear to be relatively small. But this is mainly because successive Governments have not sat idle while environmental damage has been incurred.

- This leads on to the second issue to incorporate, which is the cost of tackling environmental problems. If we denote the share of output used for this purpose as "s", and assume (for simplicity) zero damage, then we obtain:

  $r_y = (r_T + \alpha.r_K + \beta.r_L + \kappa.r_R)/(1+s)$

  such that action to tackle environmental problems leads to a reduction in economic growth. The value of "s" over time is difficult to estimate. Pearce and Palmer (2001) estimate it to be 1–2% of GDP for most OECD countries.[133] And an assessment of the measures that have been taken in the past to reduce pollution of water, land and air suggests that it is a significant number. Projections of the likely impacts of global warming suggest that it will remain large in the future – particularly in the context of the Precautionary Principle, which requires that early action is taken to avoid the worst outcomes where there is uncertainty.

- Finally, and crucially in the context of resource productivity, the standard formulation ignores the potential benefits of action to reduce environmental damage. It has already been noted that improvements in resource productivity can make an important contribution to sustainable development. And many of these contributions will show up in economic growth. An oft-cited example is the so-called "Porter hypothesis", which suggests that the stimulus to environment- and resource-enhancing innovation provided by environmental regulation and economic instruments can have a stimulating effect on innovation more generally. If these benefits per unit of output are denoted "b", we obtain:

  $r_y = (r_T + \alpha.r_K + \beta.r_L + \kappa.r_R)/(1+s - b)$

  so that if the benefits are sufficiently large, the net effect of action to tackle environmental problems can be to increase economic growth. Again, evidence is limited. But the potential is considerable.

Natural resources and endogenous growth models

A number of models have been recently developed to assess the role of natural resources in the context of endogenous growth theory. As with the theory more generally, these are primarily algebraic models, with empirical testing not yet attempted.

The focus of these models is to assess what happens to the balanced growth path of the model with endogenous growth, when natural resources are incorporated. The main conclusion is that natural resource use, resource productivity and environmental policy will have an impact on long-run growth in the context of these models.

[133] Pearce, D and Palmer, C, "Public and Private Spending for Environmental Protection: A Cross-Country Policy Analysis", UCL, (2001).

The key conclusions from the literature are as follows:

- Long-run economic growth cannot be based on resource depletion. This means that innovation to improve resource productivity and find alternatives to non-renewable resources will be key to delivering long-run growth.[134] This will require investment in man-made assets such as physical, human, organisational and institutional capital. Because diminishing returns are assumed to apply to all capital assets, long-run growth will depend on knowledge accumulation and technological change.
- In endogenous growth models, not only does environmental policy affect both the level and growth rate of GDP,[135] but also the direction of technological change. Different effects tend to work in different directions. A common theme[136] is that although action to tackle environmental problems will tend to increase costs in the short run, it can also have a longer-term impact on the relative productivity of different factors, and through effects on innovation. In some models,[137] the effect is positive, and this may result in a trade-off between short-run costs and long-run gains.
- If the Government's policy objective is to deliver an optimal balanced growth path taking into account the environment, the presence of other market failures means that traditional environmental policies cannot be pursued in isolation if we are to achieve the optimal "correction". One model of a decentralised economy[138] features a subsidy to those purchasing from monopolies at above-marginal cost, a subsidy to r&d to internalise the positive externalities and the use of pollution permits. The results show that it is the interaction between the different instruments that will deliver the optimal growth path. By implication, the optimal approach to any two instruments will differ if the other is not available, though this is not explicitly addressed.

Conclusions

This annex has argued that models of the production function and of economic growth need to undertake the next stage of their evolution. Arguments have been put forward for why natural resources, including pollution sinks, and resource productivity are an important part of the production function, and how they can contribute to or detract from economic growth. Simple models based on the standard neoclassical and endogenous growth approaches have been used to illustrate these effects, and the literature has been surveyed to identify the key results from more detailed models based on endogenous growth theory. All show that natural resources and resource productivity have an impact on economic growth – and in many cases, action to tackle environmental problems will be beneficial for growth.

[134] Smulders (2000), op cit.
[135] Smulders (2000), op cit.
[136] See for example Butter, FAG den and Hofkes, MW, "Endogenous technology and environmental quality in economic models", International Journal of Technology and Management (2001). The same conclusion is mirrored in Mabey et al (1997, op cit), who find that in the long term, there could be trade-offs between development of labour-enhancing and resource-enhancing capital.
[137] See for example Grimaud, A, "Pollution Permits and Sustainable Growth in a Schumpeterian Model", Journal of Environmental Economics and Management (1999).
[138] Grimaud (1999), op cit.

ANNEX G: DEALING WITH WASTE

Waste policy is arguably the next biggest environmental challenge facing the UK after climate change.[139] Generation and disposal of waste is closely linked to resource productivity. Action to cut down on waste generation will centre on the delivery of resource productivity improvements, by getting more from less. And if recycling and composting can provide alternatives to landfill as a means of waste disposal, they will not only cut down on the adverse environmental impacts associated with landfill sites, but will also mean that secondary materials are used instead of finite primary materials.

However, progress to date has been limited. This is mainly because landfill, despite the landfill tax, remains a relatively low-priced and accessible option. There has also been limited introduction of additional instruments operating alongside the tax, which would incentivise industry to develop more resource efficient means of production in order to eliminate and reduce waste. And industry understanding of the costs and benefits compared with disposal is limited. A Performance and Innovation Unit (PIU) discussion paper available on the PIU website[140] explores in more detail some of the options for taking forward waste policy. This annex highlights some of the key issues.

The waste hierarchy

Resource productivity in the context of the waste hierarchy is about minimising material input while maximising output. On the basis of relative environmental costs and benefits, the waste hierarchy, as set out in the Waste Strategy 2000,[141] is in the following order (most preferable first):

(i) reducing waste;

(ii) re-using waste;

(iii) recovery (recycling; composting; energy recovery); and

(iv) only then disposal.

("Optimising resource use" might arguably be added to the top of the traditional hierarchy.)

In practice, there will of course be trade-offs within the hierarchy. There are also cases where the Best Practicable Environmental Option (BPEO) for a type of waste may be some way down the hierarchy. For example, recycling may not be the BPEO if the costs of recovery or transport emissions associated with this are too high compared with landfill. Also, the hierarchy does not take account of alternative technologies, such as gasification and pyrolysis, which can reduce the harmful impacts of options lower down the hierarchy, or requirements for pre-treatment of waste to landfill.

[139] Recent studies also show links between these challenges, with the mix of waste management options impacting significantly on climate change mitigation. See US Environment Protection Agency (EPA), "Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste" (1998); Murray, R, "Creating Wealth from Waste", DEMOS (1999).

[140] http://www.cabinet-office.gov.uk/innovation/home/home_nf.htm

[141] DETR (2000), op cit.

The hierarchy reflects a desire by Government to shift waste practice over time. But national waste policy (such as the statutory recycling/composting targets) has been most heavily influenced by the need to meet the Landfill Directive targets.[142] Although the hierarchy is included in the Directive,[143] in practice the BPEO has been the guiding principle when decisions are taken regarding the different waste management options, with the hierarchy acting as a checklist in developing local level waste policy. However, it has been stressed that the hierarchy will continue to influence EU-level waste policy into the future.

The current position

Current waste management practices focus on reducing waste once it has been produced. We produce around 78 million tonnes of industrial and commercial waste per year, around 54% of which is landfilled. We also produce around 28 million tonnes of municipal waste annually (a figure growing at some 3% per annum), some 83% of which is landfilled.[144] The Landfill Directive is an overarching driver to reduce landfill, but there are others – practical, economic and environmental. In some areas of England and Wales space for landfill is simply running out, requiring transporting waste to landfill sites over greater distances – acquiring greater costs and environmental impacts.

Environmental concerns are also raised in protecting green belt and agricultural land from landfill development. Further planning constraints might also be anticipated.

Assessment of the UK policy response

UK policy has had a significant impact in reducing levels of inert waste[145] to landfill. The landfill tax was set to capture the estimated external impacts associated with waste disposal. Although there is some discrepancy in analysis of these external costs, on balance these are thought to be around £3–4 per tonne landfilled.[146]

However, landfill costs remain amongst the lowest in Europe.[147] The Waste Strategy included proposals for tradable permits covering landfilling of biodegradable municipal waste, in order to meet the Landfill Directive targets, and statutory targets for local authorities to raise recycling levels to meet the Strategy's recycling targets. The landfill tax was set at a level to internalise external costs, but it appears that significantly higher levels would be required to stimulate any particular behavioural change. This may be because particular targets are not justified by the level of external costs, or because there are other barriers which prevent waste diversion and minimisation from taking place. For example,

142 Details available at http://www.europa.eu.int/eur-lex/en/lif/dat/1999/en_399L0031.html.
143 The EU Framework Directive on Waste is the main Directive controlling waste management.
144 Figures from DEFRA's Waste Strategy 2000 and are based on waste production figures in England and Wales, 1998/99. Figures quoted exclude construction and demolition waste.
145 'Inert' as opposed to 'active' defined here as waste which does not undergo any important physical, chemical or biological transformation, and which would not be likely to cause environmental damage or endanger human health should it come into contact with other matter.
146 Estimates for external costs from landfill (£/tonne landfilled) quoted in Hogg (2001), op cit, (using a 2000 study) range from 1.04 to 16.62 for landfill with no gas collection (high figure calculated from assuming unit damage costs were at their high values and vice versa). Other evidence quoted in the same report (using a 1993 study) cites £/tonne landfill external costs as 3.45 for existing urban landfill without energy recovery and 4.06 for existing rural landfill without energy recovery.
147 For example, landfill costs in Paris are around £33.50 per tonne excluding landfill tax for non-hazardous dry waste, compared with average landfill disposal costs of £16 per tonne in the south of England. Average costs to landfill hazardous waste are £20 per tonne in the UK, the French comparison is currently positioned at £105 per tonne (figures provided by ONYX).

in the municipal waste sector the tax focuses on one point in the supply chain (contract negotiation by local authorities) and, as happens in a number of countries, is not passed explicitly through to householders – hence they have limited or no incentives to recycle.

At the top of the waste hierarchy, a number of obstructions exist (see section 1.4.1 of the main report), creating a clear gap between what would be cost-effective and what is being implemented in terms of investing in waste minimisation. Incentives for waste minimisation tend to be confined to the price of primary materials and financial costs of treatment and disposal. While some businesses are starting to minimise and reduce their waste,[148] they are in the minority.

Moving down the hierarchy to recycling, incentives are severely limited to mechanisms such as recycling credits for waste collection authorities in Great Britain, which reflect the marginal costs of treatment/disposal (but not collection). The environmental benefits of recycling are not captured and there appear to be barriers and market failures in creating sufficient markets for recyclates compared with other waste treatment options, limiting the opportunities for business participation.[149] There are some product standards in existence that unnecessarily prevent recycled materials being used where they would be fit for the intended purpose, and these should be revised. Alongside this, there is also a need to promote a more positive view of recycled material. Even where there are markets, prices do not reflect the external benefits of recycling, which arise largely because of their displacement of primary materials.

Some of the current political arrangements have tended in the past to skew the overall balance in favour of incineration.[150] For example, the exemption of energy from incineration in the Climate Change Levy, and proposed inclusion of new incineration technologies in the Renewables Obligation (RO),[151] effectively subsidises some forms of incineration, when this otherwise might not be the most cost effective waste disposal method. Opinions differ considerably as to the environmental benefits of "new" incineration technologies, though the crucial factor must be the environmental impact of what is being displaced. Institutional and political arrangements are expanded on in the PIU discussion paper available on the website.

Tackling the waste issue

Problems need to be tackled all along the supply chain. Various instruments such as the aggregates tax, producer responsibility directive, statutory recycling targets for local authorities and tradable permits for landfilling biodegradable municipal waste, as well as the landfill tax, are designed to address problems at different points in the supply chain. These are discussed further in the PIU discussion paper available on the PIU website. Overall, it is important to consider how we can better optimise resource use so that the negative effects of extracting and processing materials (including impact from energy use, emissions and discharges to the atmosphere and water)

[148] See Box 1 on the work of Envirowise.

[149] WRAP (Waste and Resources Action Programme) are addressing barriers to the lack of markets for waste minimisation, reuse and recycling, e.g. market confidence, as well as stimulating take up of recovered materials – see action plan on website http://www.wrap.org.uk.

[150] Although in individual cases public sensitivity to incineration has resulted in planning difficulties.

[151] DTI's Renewables Obligation statutory consultation proposes to include new technologies such as pyrolysis, gasification and anaerobic digestion within the Obligation. Energy from biodegradable waste will attract subsidy, but not if incinerated in combination with non-biodegradable waste.

can be reduced. This was highlighted in a recent report from ACBE.[152] It is also important that mechanisms are put in place to better reflect the external benefits of waste management options higher up the waste hierarchy. As well as minimising material waste in production processes, the lifetime of materials need to be maximised through switching to more durable products or better design for recovery/recycling.

Recommendations in the context of resource productivity

The Government's waste policy needs to be viewed in the context of the mix of policy actions it will take in its wider pursuit of sustainable development. There are trade-offs and synergies to consider in terms of effects on labour, resource and capital productivity, which will have a bearing on waste policy. Examples are provided in the PIU discussion paper available on the PIU website.

It is also important that there is a clear strategy for meeting long-term landfill targets so that industry has the confidence to invest in alternative waste disposal and treatment options. Arguments for raising the level of the landfill tax should be carefully considered in the light of evidence on the level of external costs and any desired change in behaviour. Any rise in tax would need to be approached gradually and with long-term signals as to intended direction, so as not to burden business and force quick fix routes. Accompanying policy instruments will need to steer those involved towards more attractive alternatives. The impact of other potential measures, for example, an incineration tax on non-biodegradable waste, or fiscal instruments to encourage combined heat and power, should be subject to continual review. Considering how the planning system can best facilitate this will be key.[153]

A dynamic programme of pull mechanisms and incentives is needed. This might range from extending recycling credit schemes, to engaging the public/businesses more with the issues, to encourage a bottom-up culture shift. In addition to the market-based and other mechanisms outlined, additional policies need to be considered, such as emphasising the importance of Government departments taking the lead in developing further green procurement policies.

[152] ACBE, "Resource Productivity, Waste Minimisation and the Landfill Tax" (2001), available at http://www.defra.gov.uk/environment/acbe/landfill/index.htm.

[153] For example, the Government is considering "parallel tracking" planning and environmental permits to accelerate the development of waste facilities.

ANNEX H: THE DOW JONES SUSTAINABILITY GROUP INDEX AND FTSE4GOOD

The financial markets are waking up to the importance of sustainable development. Socially responsible private investors are beginning to demand opportunities to invest in companies with excellent performance against environmental and social objectives, as well as against financial objectives.

Socially responsible investment is not a new concept, and has been offered by pioneering companies for some 20 years. One of the more recent responses to this demand was the launch in September 1999 of the Dow Jones Sustainability Group Index (DJSGI). DJSGI is owned by Dow Jones, Stoxx Ltd and SAM Group. The central world index is accompanied by a suite of regional indices (including a recently announced European index) and specialised indices, which explicitly exclude certain industries such as alcohol, tobacco and gambling. The index is made up of the top 10% performers in each of 64 industry categories, measured against a series of economic, environmental and social criteria. (The European index includes the top 20% performers from a list of 600 companies.) Whole industries are excluded if even the best performers are not up to scratch. Current top performers in key sectors are as follows:

Bayerische Motoren Werke (BMW) AG	(Consumer Cyclical)
BG Group Plc	(Energy)
Bristol-Myers Squibb Co	(Healthcare)
Credit Suisse Group	(Financial)
Deutsche Telekom Group	(Telecommunications)
Dofasco Inc	(Basic Materials)
Fujitsu Ltd	(Technology)
Procter & Gamble Co	(Consumer, Non-Cyclical)
Sulzer AG	(Industrial)
Thames Water Plc	(Utilities)

More recently, July 2001 saw the launch of FTSE4Good, a series of indices for socially responsible investment designed by FTSE. FTSE4Good excludes companies involved in producing tobacco, weapons or nuclear power. It then selects from the remaining list of companies on the basis of their performance against indicators of environmental sustainability, social issues, stakeholder relations and human rights. Different indices cover different regions and company sizes (based on market capitalisation).

The demand for investment opportunities such as DJSGI and FTSE4Good shows that some investors are beginning to attach a premium to companies which are taking seriously their role in delivering sustainable development. Over the long term, it would be hoped that this would be reflected in the performance of DJSGI and FTSE4Good indices relative to the market as a whole.

There is some evidence to suggest that this is already the case. Figure H1 compares the return on the DJSGI versus the standard Dow Jones Group Index (DJGI) extrapolated back over a five-year period, and shows that the return on the sustainability index is greater than that on the standard index in all regions. Figure H2 shows that the FTSE4Good UK 50 Index (top 50 UK companies on the list, measured by market capitalisation) has outperformed the FTSE 100 and All Share Indices over a similar period. Of course, these figures should be treated with caution as they do not control for market risk.

Figure H1: Five-year price return on Dow Jones Sustainability Group Index (August 1995 – August 2000; Euro denominated price index)[154]

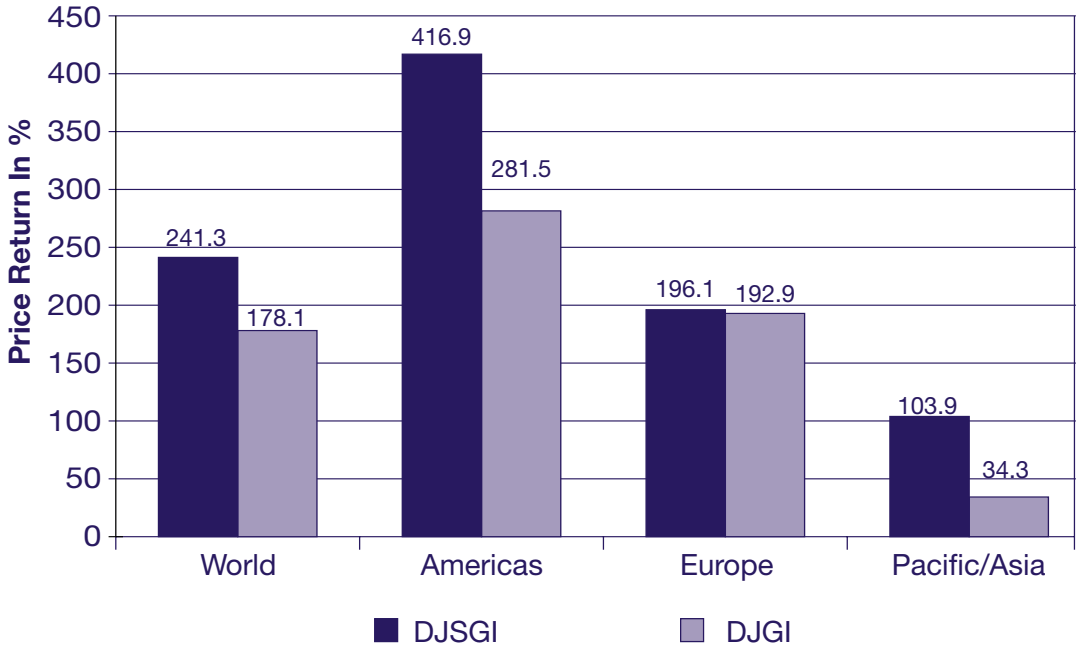
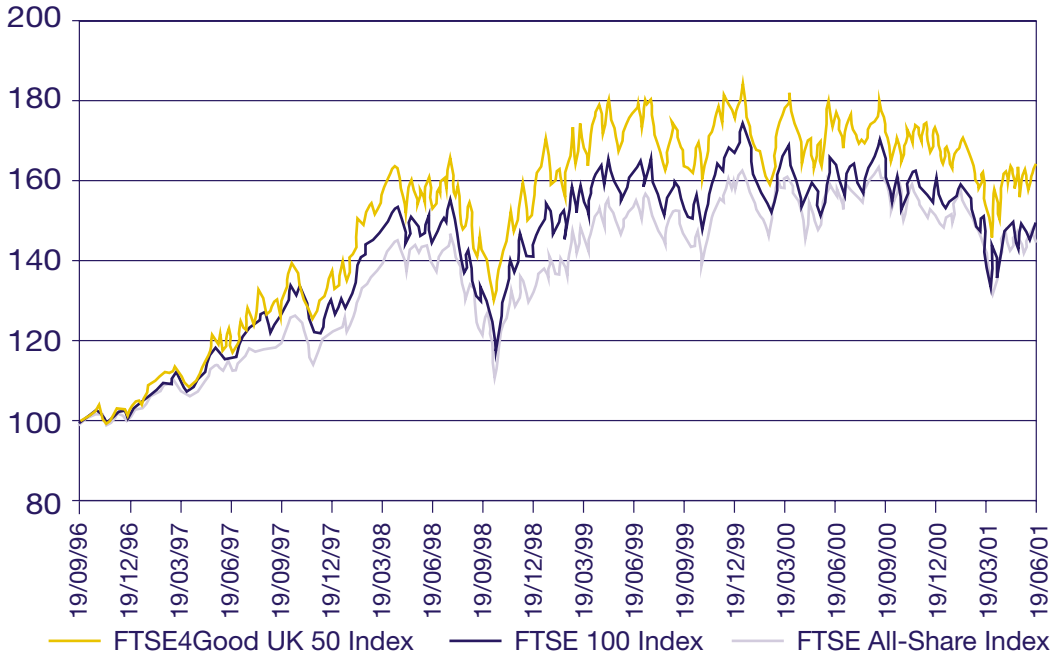


Figure H2: Five-year performance of FTSE4Good UK 50 Index (September 1996 – June 2001)[155]



[154] Figure taken from presentation given on the occasion of the DJSGI's first anniversary, at http://www.sustainability-index.com/news/press.html.

[155] Figure taken from performance analysis at http://www.ftse4good.com/frm_indexp3.asp.

ANNEX I: THE ROLE OF INNOVATION

Introduction

Innovation is the generic term for the successful development of a new idea – a new product or service, or the production and bringing to market of that new product or service. An important area in the study of the economic and social impacts of innovation is concerned with understanding the nature of the innovation process – *what* innovation is and *how* it is delivered – which in turn requires an understanding of the actors involved, and what motivates them. This annex provides a brief overview of the general issues involved. These underpin the principles of policy support for resource productive innovation that are highlighted in the main document.

Types of innovation

Innovations can broadly be characterised as institutional or technological. Institutional innovations are improvements in the way organisations operate, or the creation of entirely new organisations. The development of credit banking is an institutional innovation, as is total quality management. Institutional innovation tends to come about through mechanisms that are more difficult to analyse than technological innovation. Institutional innovations reflect new modes of thinking, changed organisational priorities, and cultural or social paradigm shifts.

Technological innovations are a bit easier to track because they involve changes to physical objects which can be measured directly, categorised and analysed. Technological innovations can occur in products and processes. Product innovation refers simply to the development of a new or improved product – a faster personal computer for example, or a quieter vacuum. Process innovation refers to the method by which products are made. Materials substitution or ease of manufacturing are examples of process innovations.

The innovation "cycle"

Technological innovations are often considered to follow a general progression from basic r&d, to full commercialisation, widespread diffusion, and eventual obsolescence. The core process is sometimes referred to as the innovation "cycle" which can be considered to have several steps – basic r&d, applied research, demonstration, commercialisation and diffusion. However, this does not imply that each and every innovation must go through all of these steps, or that there is a simple and linear process for delivering innovation that starts with r&d and ends in a new product, process or service. Each stage just described frequently influences the other stages, and different stages often coexist with one another. In addition, the different actors involved in the innovation cycle are now widely recognised to relate to each other via a network.

Each stage of the innovation cycle is faced with unique challenges and characteristics, as briefly sketched overleaf.

Basic r&d

- No obvious commercial application
- Longer term or "blue skies" research
- Element of chance

Applied r&d

- Potential commercial application
- Shorter term

Demonstration projects

- May require significant increase in funding and effort
- Challenges are financial, technical and informational

Commercialisation

- Requires another injection of finance and acceptance in the market
- Reactions of existing firms, technologies and customers

Diffusion

- Signifies ultimate success of the innovation

The difficulties in making the transition from applied research to a demonstration project have been captured by the term "Valley of Death".[156] At this stage, the project is often too uncertain or small scale to attract major funding from, for example, venture capitalists, and therefore frequently relies on seed money from Government matching funds, university development programmes, or other so-called "angel investors". This is a particularly challenging stage in developing a technological innovation. For similar reasons, the term "Mountain of Death" has been used to describe the difficulties in the massive scaling up required to get to full commercialisation.

Incremental, radical and disruptive innovations

Innovation means a departure from the usual ways of doing things, but there are varying degrees of departure. The terms "incremental", "radical" and "disruptive" have been used to distinguish differing degrees of innovation and, importantly, their impacts. An incremental innovation is a small change, a minor improvement along the lines for which the product or process is currently valued. A radical innovation is a dramatic improvement along those same lines, while a disruptive innovation represents a transition to a new technology or a new paradigm.[157] A disruptive innovation often results in changing the way people think about the product, process or institution, and in developing new characteristics that are subsequently expected by users. Disruptive innovation also often results in a change of leadership in affected industries and may deliver entirely new industries.

Most studies of innovation tend to focus on disruptive innovation. This is understandable, since disruptive innovation often has wide reaching, profound impacts. However, the importance of gradual, incremental innovations over time should not be overlooked. Though incremental innovation is not perhaps as dynamic as disruptive innovation, it has been estimated that half of the technological and productivity advances, and half the economic benefits from new technologies, are due to incremental innovation.[158] It is true that this number is approximate, in dispute, and varies across industries. Nevertheless, it must be borne in mind that, to the extent we concentrate on disruptive innovation, we may only be looking at half of the total picture.

[156] Branscomb, L and Auerswald, P, "Taking Technical Risks: How Innovators, Executives, and Investors Manage High-Tech Risks", Cambridge, MA: MIT Press (2001).
[157] Disruptive innovations can also follow the valued attributes of the old technology, but it is much more likely that those attributes will be delivered in a new way.
[158] See Christensen, C, "The Innovator's Dilemma", New York: HarperBusiness (2000) and Utterback, J, "Mastering the Dynamics of Innovation", Boston: Harvard Business School Press (1996).

It must be stressed that incremental, radical and disruptive innovations do not necessarily imply a particular time horizon. Nor do the different types of innovation imply degrees of newness. An idea or a technology must only be innovative in a particular environment or application, not necessarily new to the universe.

A final distinction that is frequently made between different types of innovation is whether they are competence enhancing or competence destroying. Competence enhancing innovations draw on the knowledge and skills that were used to create the technology that is being replaced. Competence destroying innovations render obsolete the expertise acquired from the superseded technology. It is important to be careful when using these terms, because whose competence is being enhanced or destroyed, and, indeed, the very notion of enhancing or destroying, depends on a particular perspective.

Innovation actors

There are many individual and institutional actors involved in the development of an innovation. In a wider sense, innovation at its root is a social phenomenon, influencing, and influenced by, history, culture, education and the political, institutional and economic structure of society.[159] Innovation can be the response to a wide number of policy initiatives, including industrial policy, environmental policy, competition policy, tax policy, enterprise policy, research policy, etc.[160] Nevertheless, the three primary actors are often considered to be universities, industry and Government, and each of them has unique motivations and limitations to their involvement.

Universities

Analysis of innovation has often focused on university-based research, and university r&d has indeed been important in industry's technical advance.[161] Universities provide two types of inputs into the innovative process: blues skies research and applied r&d, and *human capital*. However, it is rather simplistic to think of universities as engines of economic growth, to consider their laboratories as the origins of all successful innovations, or to conclude that a perceived "lack" of innovation is the result of a deficit in basic r&d. Such a view implicitly relies on the notion of a linear innovation process where university r&d leads to innovation in a relatively straightforward way such that "r&d in = innovation out". This is not to say that university r&d does not contribute toward innovation – it certainly does. However, much more is required than simply increased r&d in order to turn a new invention or discovery into a commercially successful innovation. Universities are only one node in an interconnected network of innovation actors.

Industry

Even when developed through Government funding or in university laboratories, at some stage innovations must emerge into the marketplace, and this means that innovation is frequently guided (and resisted) by private, profit seeking actors. There is a considerable literature on the interaction of firms, industries and products with the innovation cycle, and in order to design policies that encourage innovation it is important to understand the basic dynamics of innovation within firms and sectors.

[159] European Commission, "Green Paper on Innovation" (1995).
[160] European Commission (1995), op cit; EC, "Innovation in a Knowledge-Driven Economy" (2000).
[161] Brooks, H and Randazzese, L, "University-Industry Relations: The Next Four Years and Beyond", Chapter 14 in Branscomb, LM and Keller, JH (Eds.), *Investing in Innovation: Creating a Research and Innovation Policy that Works*, Cambridge MA: MIT Press (1999).

It is widely recognised that leading firms in a particular industry have great difficulty adapting to or delivering disruptive innovations.[162] It has been estimated that in around three out of four occasions, disruptive innovations result in a change of industrial leadership.[163] This changeover is often referred to as the arrival of new entrants, though it is worth bearing in mind that new entrants can be new firms, large firms moving into a new area of business, or spin offs/outs from established competitors. It is also important to note that the arrival of new entrants may be hampered when initial capital costs, or other barriers to entry, are particularly high.

Of course, these general statements do not hold across the entire range of different types of innovations in different markets. For example, one useful distinction is the difference between assembled and non-assembled products.[164] Firms outside an industry are most likely to deliver disruptive innovations if they are in assembled products, expand established markets, and are competency destroying. Conversely, disruptive innovations almost always come from within the industry if they are in non-assembled products, substitute for established products, and are competence enhancing. If two of these three factors favour outside innovators, outside innovators are again almost always responsible for the innovation. If only one factor favours outside innovators, there is about an equal chance that the innovation will come from an insider or an outsider.

Government

The principle motivation for Government intervention to promote innovation is the importance of innovation and r&d in maintaining high and stable economic growth.[165] It is argued that "innovation and research and development (r&d) are catalysts for productivity growth, acting to open up new markets and new opportunities for firms through the creation of new and improved products, services and processes".[166] As a result there are a wide range of programmes underway, at both UK and EU level,[167] and many associated policy papers.[168]

The key traditional role for Government has been as the sponsor of basic r&d, leaving the development and commercialisation of new ideas to the private sector. There are good reasons for this: innovation brings positive externalities, social returns from r&d exceed private returns[169] and, at the basic research stage, many innovations remain public goods, as it is often neither possible nor desirable for all of the benefits to accrue solely to the innovator. Without intervention, this would give rise to a market failure that has the potential to stymie innovation – a lack of incentive for innovative activity. The second role of Government (or more precisely, the legal system) has therefore been to provide a framework of intellectual property rights that ensure innovators can appropriate sufficient rents from the commercial development of new ideas.

[162] Christensen (2000) op cit; Utterback (1996) op cit; Porter, ME, "The Competitive Advantage of Nations", New York: The Free Press (1990).
[163] Foster, R, "Innovation: The Attacker's Advantage", New York: Summit Books (1986); Utterback (1996), op cit.
[164] Assembled products include things like typewriters, televisions and cars, and often require many steps in manufacturing, use multiple materials, and require many parts. Non-assembled products typically use fewer materials and have fewer manufacturing steps. Examples of non-assembled products are items such as glass and chemicals.
[165] HMT, "Increasing Innovation: A Consultation Paper", (2001).
[166] HMT (2001) op cit.
[167] EC (1995) op cit; EC (2000) op cit; EC, "European Trend Chart on Innovation Country Report: United Kingdom", (2000a). Available online at http://trendchart.cordis.lu/Reports/index.cfm?.
[168] DTI, "Excellence and Opportunity: A Science and Innovation Policy for the 21st Century (2000); DTI, "Opportunity for All in a World of Change" (2001); HMT (2001) op cit.
[169] See Margolis, R and Kammen, D, "Evidence of under-investment in energy r&d in the United States and the impact of Federal policy", Energy Policy 27 (1999); Borrus, M and Stowsky, J, "Technology Policy and Economic Growth", Chapter 2 in Branscomb, LM and Keller, JH (Eds.), "Investing in Innovation: Creating a Research and Innovation Policy that Works", Cambridge MA: MIT Press (1999); HMT (2001) op cit.

One reason for limiting primary intervention to these areas is Governments' oft-cited lack of success in "picking winners". Nevertheless some intervention further "along" in the innovation cycle is also commonplace in the UK and elsewhere – through demonstration projects for example – and recent policy has indicated a willingness to do more to help ensure that new ideas give rise to commercial success.[170]

Innovation and resource productivity

As mentioned above, economic externalities are one reason why Government intervention is required to deliver innovation. In a number of important fields, including resource productivity, these positive externalities have an additional dimension. Innovation can improve living and working conditions, or address the concerns of the ageing or disabled.[171] Innovations can also result in increased efficiency of production processes, or in changed product characteristics that lower environmental impacts. Technological progress through innovation is at least partially responsible for the apparent decoupling of economic growth from energy use and carbon emissions.

In fact, in many sectors and across a wide range of countries a steady increase in resource productivity has been realised over time. However, in general, this has not been sufficient to keep pace with increasing consumption, and resource use and a number of significant environmental impacts have continued to increase.[172] The key issue is therefore whether policy can do more to promote resource productive innovation.

The role of policy

The arguments above indicate why basic r&d is often under-funded in the private sector. However, there is an additional dimension to this when considering resource productivity. Whilst it is both possible and important for state-supported r&d to target resource productivity, development through to commercial exploitation requires private sector involvement and therefore is profit oriented. This means that innovation is most likely to deliver improvements in areas that are readily valued in the market. But resource inputs are a small fraction of most companies' budgets and given many possible avenues for innovation and limited resources, firms will not choose to undertake innovations with smaller returns or higher risks. Even where environmental externalities are fully internalised, incentives to direct innovative effort towards resource productive ends may be limited.

This suggests that policies aimed at improving resource productivity must do two things: Firstly, resource productivity needs to be placed at the heart of existing innovation and r&d policy. Secondly, policy support for resource productive innovation must not just target the basic r&d stage, or simply provide incentives for commercialising resource productive methods, but provide support at all stages, particularly the stages that are most likely to "block" innovation.

The principles of policy intervention are restated overleaf. Effective support for innovation requires that the innovation process is understood; in particular how it differs between types of industries and within industries over time. This provides a context in which policymakers can prioritise and tailor policy instruments to suit circumstances, helping to accelerate

[170] DTI (2000), op cit.
[171] EC (1995), op cit.
[172] Berkhout, F, "Aggregate Resource Efficiency: A Review of the Evidence", in Vellinga, P, Berkhout, F and Gupta, J (eds.), *Managing a Material World: Perspectives in Industrial Ecology*, London: Kluwer Academic (1998).

the innovative process in as wide a range of sectors and activities as possible.

Other considerations, such as a modern infrastructure, a skilled workforce and access to capital, are also important if the full benefits of technological innovation are to be realised.[173] Such factors have always been central to the development of an innovative and growing economy. But successful policy may be able to direct innovative effort to capitalise on the synergies between improved competitiveness and other Government objectives, building wealth and increasing resource productivity.

Principles of support for innovation

- Ensure that support for basic r&d targets resource productivity, and that this research is adequately resourced. Relevant areas will include material science, advanced systems design and biotechnology.
- Assist firms and universities in bridging the gap between research and commercial development. Some benefits could arise by including "resource productivity" or "sustainable development" as a suitable heading for designing LINK programmes.
- Strengthen public-private venture fund partnerships focused on delivery of resource productive innovation and investment.
- Create "niche markets" that enable new products and practices, not yet competitive with established alternatives, to benefit from "learning by doing" and gain economies of scale. One way of establishing niche markets is through "greening procurement" (see section 4.2.4).
- Address barriers within industries, including financial barriers (e.g. access to capital for smaller companies with innovative products) and structural (e.g. where new entrants are excluded and where incumbents are likely to be unwilling to innovate).
- There are also industries where the incumbents themselves are more likely to be the main source of innovation, and where innovations are more likely to be incremental (for example in highly complex and capital intensive process industries). In such cases incentives for resource productive innovation are all important.
- Incentives for innovation can involve variants on the standard instruments – but a focus on driving innovation suggests two key features:
  - Maximum flexibility for companies to find innovative solutions themselves – outcome-based targets or standards backed by regulation or fiscal incentives.
  - Sufficient time for innovation to come on stream – which suggests clear and long-term commitments to staged implementation of targets or standards.
- New incentives may also be created, such as "back-loading" support for innovation (as opposed to front-loading through the r&d programme) with a financial prize for resource productive products, or perhaps a secure niche market.

[173] Borrus and Stowsky (1999), op cit.

ANNEX J: ELECTRICITY MARKET LIBERALISATION AND INNOVATION IN A CARBON-CONSTRAINED WORLD

Electricity market liberalisation in the UK

Resource productivity in the context of electricity markets means the provision of increased light, heat and power while using less fossil fuels and hence reducing levels of emissions. In this context it will be important to consider the role renewable forms of generation can play in the electricity market, although a range of other factors, including energy efficiency and demand management, must also be taken into account.

The process of liberalisation in the UK electricity market over the last decade has had important implications for the level of innovation and carbon emissions in the sector. Liberalisation took place over a 15-year period starting in the mid 1980s, and entailed the privatisation of the gas, electricity and coal industries and a gradual increase in the level of competition. The process of liberalisation can, in itself, be seen as a form of institutional innovation that has brought about economic benefits for energy consumers by increasing productive and allocative efficiency in the electricity market.[174] However, this policy has not been fully reconciled with other Government objectives on innovation and sustainability. The serendipitous combination of lower energy prices and reduced emissions was largely an incidental result of gas replacing coal in power generation.

A full discussion paper on this subject, which is available from the Performance and Innovation Unit (PIU) website,[175] highlights how a resource productivity framework can be used to balance the needs of competing economic, environmental and social objectives and explore the potential synergies and trade-offs between them. A full review of energy policy is currently being undertaken by the PIU and will also consider many of these issues.

The importance of innovation

The Government's commitment to the Kyoto Protocol,[176] and the longer-term implications of the recent Royal Commission on Environmental Pollution report,[177] mean that innovation in the electricity sector will be vital in order to deliver low carbon systems of generation in the future. The evidence presented in the discussion paper on the web suggests that there were both positive and negative implications from the process of liberalisation. Under the privatised system energy r&d was focused in large nationalised companies, leading to low levels of efficiency in the use of r&d funds. Market liberalisation increased the efficiency with which r&d expenditure was used but this had implications for both the level and types of investment that were made. Maximising the private returns to innovation may tend to undervalue, relative to the social benefits, innovation that may lead to resource productivity improvements. Further, owing

[174] Productive efficiency means that the economy is operating at lowest cost. Allocative efficiency means that resources are allocated to the goods and services that are most valued by society.
[175] http://www.cabinet-office.gov.uk/innovation.
[176] UNFCCC (1997), op cit.
[177] RCEP (2000), op cit.

to a divergence in discount rates between private and public companies, liberalisation has tended to reduce the time horizon for innovation to focus more on shorter-term goals. While it is recognised that there is not yet sufficient data available on r&d outputs to confirm this hypothesis, there is enough evidence to raise concerns about the implications of electricity market liberalisation for the development of new, more resource productive technologies and processes. It is therefore unlikely that the liberalised market, in its current form, will on its own be able to deliver all of the Government's objectives. This may be particularly true if electricity companies do not receive the appropriate financial incentives to reduce carbon emissions.

The discussion paper addresses the rationale for Government intervention to increase the level of innovation within the electricity market, drawing on the analysis carried out of innovation more generally (see Annex I). However, it is imperative that this is set in the broader context of resource productivity, in order to maximise the synergies while minimising the trade-offs. For example, the paper highlights that one of the barriers to innovation may be the system of connection to the electricity grid that is still largely based on 1970's technologies. Updating this system to explicitly consider new technologies, while not without costs, may have much wider economic benefits as well as boosting the level of innovation. In contrast, trade-offs may arise from policies that seek to internalise externalities and reflect these costs in the market price for high emission fuels. For example, higher prices would impact on those suffering from fuel poverty in the UK, largely due to outdated and substandard property.

Analysis of the issues

Central Government would appear to be the best placed organisation to balance the competing objectives described above, and is seeking to do so in part through the PIU review of energy policy. Ofgem, the electricity industry regulator, is currently precluded from carrying out the function of promoting innovation, and there are dangers that such a task might interfere with Ofgem's primary responsibility as the economic regulator for the industry. However, it will be important to ensure that Ofgem's objectives do not conflict with the pursuit of wider environmental goals. The Government needs to send out clear long-term signals about its commitment to renewable energy and the Renewables Obligation plays an important part in this. Such a commitment should be set within a long-term energy policy vision that takes account of the potential for development of decentralised generation and energy service providers. In this way the interaction between promoting innovation of new technologies and ensuring security of supply from a variety of electricity generation sources can be rationalised.

Both the discussion paper and the work on innovation (see Annex I) highlight the need for Government policy to be targeted at the different stages within the innovation process. The Government already provides support for blue skies research and the demonstration of new technologies. Policies such as the Renewables Obligation are intended to increase the private returns to renewable technologies. However, the UK's funding programmes are small in comparison to other leading OECD countries such as Germany and the US. It may be necessary to increase the levels of support given in this area in order to achieve the technological improvements necessary to approach long-term emissions targets such as those suggested by the RCEP. These issues will be considered as part of the PIU review of energy policy.

It is also necessary to consider the different types of institutional and technical innovation. The nature of the market structure may have implications for the type of innovation that takes place. Thus, barriers to entry in the electricity commodity market should be targeted in order to maximise the possibilities for all forms of innovation. The Government must also consider the changing nature of the energy industry and the rising value of service contracts as opposed to directly owning equipment. Finally, an awareness of the international context of both innovation and climate change policy must be maintained. Changes in either of these may require the Government to adjust its domestic strategy.

Conclusions

Electricity market liberalisation created a complex series of interactions with the innovation process in the sector. The Central Electricity Generating Board's (CEGB's) system of innovation was inefficient with significant levels of research funding being wasted through lack of proper controls and monitoring and inadequate financial commitments by manufacturers. Liberalisation introduced commercial competition to the r&d process and with it, improved efficiency in the allocation of resources. However, there may have been costs associated with this and there is some evidence that increased competition has shortened the time horizons for r&d expenditure, creating a focus on short-term commercial goals rather than long-term investment. It may also be possible that research budgets have continued to fall beyond the extent justified as an adjustment to CEGB inefficiency. An investment pattern of this kind may prevent the development of technologies that will allow us to continue to reduce our emissions levels in the future and hence achieve all of the Government's objectives.

The Government's response to such a situation needs to be carefully considered in order to balance its economic, social and environmental objectives. The Government needs to send out clear long-term signals about its commitment to renewable energy in order to encourage innovation. The Renewables Obligation provides an important start but further actions may be necessary. The Government will also need to explicitly consider the transition away from existing infrastructures over a long-term timescale. These policies must be set within an international context and an awareness of changes in the nature of the energy business must be maintained. This may entail a move away from selling measured units of measurable energy carriers (e.g. kilowatt-hours of electricity), and towards contracting to deliver reliable energy services. The study has clearly highlighted the difficulty in trying to carry out this process and the need to take account of resource productivity in dealing with these problems. The PIU review of energy policy will be responsible for taking many of these issues forward.

ANNEX K: RESOURCE PRODUCTIVITY METRICS

Providing useful indicators and targets for resource productivity will form an important part of successfully implementing any resource productivity strategy. There are two principle conceptualisations of resource productivity and efficiency. First, physical or technical efficiency, which is the amount of material input required to produce a unit of output, material or service in the economy. Second, economic efficiency, which focuses on the money value of outputs relative to the money value of inputs and on resource cost minimisation as a goal of economic activity. This annex sets out a range of existing indicators and assesses the contribution they might make to the measurement of resource productivity.[178]

Indicators/targets of resource productivity

Material flow analysis

The material flow analysis (MFA) framework presents data on the mass of materials entering the economy, which then determines the resources that are emitted into the environment as pollution and waste.

The most well developed example is the German Material and Energy Flow Information System (MEFIS), which is a MFA framework incorporating a Physical Input-Output Table (PIOT). Another variant is the mass balance model, currently being co-ordinated by Forum for the Future and developed as part of the Biffaward series of projects.[179] The model is based on the principle that mass can neither be created nor destroyed and so the mass of inputs to a process must equal the mass of outputs. The project hopes to provide geographic and industry data on resource flows.

Each of these approaches can produce a range of indicators relevant to resource productivity. One of these is total material requirement (TMR). TMR provides an aggregate indicator that allows changes in resource use over time to be quantified and compared between countries. Germany's Wuppertal Institute recently conducted a project funded by the UK Government to derive material resource accounts and TMR for the UK. The TMR methodology does not specifically relate the levels of resource use to sustainability. However, indicators can be related to GDP in constant prices as well as expressed on a per capita basis.

Environmental space

This measure, initially proposed by Weterings and Opschoor, concerns the space available to humanity as a whole for the utilisation of stocks and sinks. This is applied to stocks that are globally tradable and sinks that are global in context. It is the recognition of global limits to the atmosphere for example, which forces us to face the issue of how environmental space is to be allocated between nations and regions.

[178] See Moffatt et al (2001), op cit for further information.
[179] Ekins et al (2001), op cit.

Ecological footprints

Developed by Rees and Wackernagel, ecological footprints provide a framework for comparing the human impact on the environment in terms of the resource consumption and waste assimilation requirements of a defined human population or economy, with the capacity of the biosphere to regenerate.

Human appropriated net primary production

Net primary production (NPP) is an ecological term for the total production of biomass from an area of land by the growth of photosynthetic green plants. The amount of NPP used directly (eaten), or indirectly (for timber products), or prevented by non-productive land use (such as roads) by humans, is termed human appropriated net primary production (HANPP). This measure is of interest for what it implies about the prospects for other species that must survive on the remaining fraction of NPP which is unused by humanity, and about the limits to the number of people that the earth can support. It is important to note that this measure is not strictly concerned with resource efficiency, but rather of the efficiency with which humanity is controlling and consuming biomass production.

Assimilative capacity

Assimilative capacity can be loosely defined as the amount of disturbance that a natural system can adapt to, or the amount of input (for example CO_2) that it can absorb, without resulting in a significant change to the structure and/or function of that system. With respect to resource productivity, the concept of assimilative capacity is best seen in connection with setting emission/discharge limits for deposited pollutants resulting from production processes.

Asset balances for environmental capital

This approach highlights the fact that all natural resources, whether renewable or non-renewable, and using the wider definition adopted in this report, can be thought of as natural assets. As with any asset, this natural capital can depreciate, for example, when forests are felled. It is also possible to invest in the natural capital stock through forest planting, for example. This measure of resource productivity measures the balance of natural asset depreciation/investment, thus giving a guide to both the level of resource use efficiency and the extent to which reinvestment is necessary. The Genuine Savings measure of sustainable development (GDP – consumption – depreciation of produced assets – depreciation of natural capital – depletion of natural assets) is an example of the asset balance approach being adopted in practice as it compares depreciation and appreciation of the total capital stock of a country.

Y/e measure

The Y/e measure is based on the idea that resource productivity is defined by Y/*m* when Y = output (measured in monetary or physical terms) and *m* is a measure of resource input (typically measured in physical terms). However, in order to include some concept of environmental impacts, the equation is rewritten as Y/e where e = emissions. Y/e then becomes an expression of output per unit of emissions.

Assessment of measures

The suitability of different measures depends primarily on three factors:

- robustness, in terms of the reliability, defensibility and sensitivity of the theory;
- practicality, in terms of the technical feasibility, data availability and the ease of communication; and

- usefulness to policy-makers, in terms of the identification of targets, gaps and trends.

In addition, all measures should link resource use to the wider goal of sustainable development.

All of the options considered here vary in their individual strengths and weaknesses, and none of them entirely satisfies all the criteria. Measuring resource efficiency in relation to sustainable development is complex and all measures are to some extent imperfect. It is therefore important to choose measures that are as appropriate as possible to the situation, while maintaining a full awareness of their limitations. In general terms, those measures that might be the most robust and useful have a tendency to suffer from difficulties in terms of their practical availability.

Overall composite indicators of resource productivity include ecological footprint and TMR measures. Ecological footprints are based on a defensible theory and have good sensitivity, but suffer from a lack of data availability and are not particularly reliable for forecasting and modelling purposes. This makes it very difficult to assign appropriate weights to the measure and can lead to subjective interpretations.

TMR is just one of the measures derived from MFA, and arguably one of the weakest due to its double-counting of trade flows. It measures both the material that enters the economic system in the form of minerals, energy and agricultural produce, and also the materials that the economy disturbs, such as mining overburden and eroded soil. The latter are termed hidden flows. The indicator is made up of four components: direct resource flows, including both domestic and imported; and hidden flows, again both domestic and foreign. Calculations of this measure show that the TMR is strongly influenced by the substantial quantities of hidden flows. TMR has also attracted criticism since the weighting does not take into account the relative toxicity and environmental damage profiles of different materials, although TMR is not the only indicator to suffer from this problem. TMR and other measures have been published by the ONS in the UK National Accounts "Blue Book",[180] and the ONS plan to update the MFA database and indicators on a regular basis.

A complementary approach to using an overall composite indicator is to have a range of measures that measure progress in different areas of the economy, such as the national, sectoral and company levels. This is also possible using the MFA approach.

HANPP, environmental space and assimilative capacity are all useful at the regional level or economy-wide level. HANPP is a robust measure based on ecological theory; but it is not particularly practical and suffers from a lack of data availability. Assimilative Capacity is also a robust measure and is more practical than HANPP but is not easy to communicate effectively. Environmental space is quite a weak measure that is not based on a defensible theory and is not particularly reliable.

Y/e measurements and asset balances can be used for individual sectors rather than the economy as a whole. This is because the problem of aggregating different inputs of materials, energy, outputs, services, products and pollutant emissions are reduced as each sector encompasses a smaller range of products and services. Both measurements are easily communicated and provide useful trend data. Compared to some other measures, asset balances are particularly strong with good technical feasibility and,

[180] ONS, "UK National Accounts – The Blue Book" (2001), available at http://www.statistics.gov.uk/products/p1143.asp.

potentially, data availability at sector level. The Y/e measurement could also be used at this level to provide a suitable indicator but may suffer from a lack of data availability, depending on the units to be used.

Conclusion

Having examined various measures of resource productivity there are reasons to be cautious about the use of a single composite indicator. It is extremely difficult to find a single measure that will fulfil all of the criteria outlined above, and a single measure can mask important details. There is also a danger that effort is diverted into debating the relative weightings of a single indicator rather than focusing on the issues at hand. A recent OECD meeting of experts expressed concerns over subjective weightings when attempting to develop an ecological footprint. However, composite indicators do have some positive factors and could be used to raise the general awareness of resource productivity issues. Indicators based on MFA would appear to have support at the European level and the UK has already published some of the indicators in the UK National Accounts Blue Book.

An alternative approach would be to employ a hierarchy of measures to assess progress at the national, sectoral and company level. This could allow reliable estimates to be made over time. The danger here is that the large range of indicators involved could prevent clear messages being easily obtained.

Ultimately there is no perfect measure of resource productivity. However, many of the concerns expressed in this paper could also be levelled at other indicators such as GDP which are readily accepted both by policy-makers and the general public. Further research may well be needed to help develop appropriate metrics for use with resource productivity.

A twin-track approach will be appropriate

Following on from these conclusions, **this report recommends a twin-track approach, focusing on the use of simple proxies in the short term, while more detailed measures are developed and measurement techniques refined**. Specifically, this should involve the following steps:

- DEFRA, ONS and DTI should work together to develop a series of simple measures of resource productivity at national and industry level. These should build on existing data (for example, the various indicators included in the Government's indicators of sustainable development[181]) and should focus on plotting headline trends over time. Similar indicators should be developed at regional level, in conjunction with the appropriate regional bodies. Key measures that should be included will be Gross Value Added (GVA) per tonne of CO_2; GVA per unit (kWh) of primary and of delivered energy; and GVA per tonne of waste arising. Use of the data will require appropriate caveats.
- DEFRA should continue to take forward interdepartmental work on the valuation of external environmental costs and benefits, developing as soon as possible agreed values (or more likely ranges) and methodologies that can be included in policy appraisal and evaluation. As a second step, DEFRA should work with ONS to develop adjusted measures of GDP and related indicators, taking into account environmental impacts. These will be based on the application of valuations

[181] DETR (1999a), op cit.

to the quantified ONS environmental accounts. Because significant gaps are likely, especially in the short term, use of the adjusted GDP figures should initially be for illustrative purposes only, and published primarily as a means of stimulating wider research and debate.

- DEFRA and DTI should review the conclusions of the TMR analysis carried out recently for DEFRA by the Wuppertal Institute in conjunction with ONS and to be published shortly. Understanding the UK's relative performance at national level, and understanding the roles of different sectors, will be particularly important. The conclusions may themselves suggest areas for policy intervention, or may point to the need for further research.

ANNEX L: GLOSSARY OF TERMS

ACBE – Advisory Committee on Business and the Environment

ACCPE – Advisory Committee on Consumer Products and the Environment

AFS – Action for Sustainability

Allocative efficiency – Achieved when resources are allocated to the production of the goods and services that society most values.

Asymmetric information – Information which is unequally shared between two or more individuals or organisations.

BPEO – Best Practicable Environmental Option

Capital – Divided into several categories. Man-made or physical capital usually taken to mean the stock of machinery, tools and buildings. Human capital usually taken to mean the stock of human knowledge and abilities. Natural capital usually taken to mean the stock of natural resources.

CCP – Climate Change Programme

CLR – Company Law Review

CSR – Corporate Social Responsibility

DCMS – Department for Culture, Media and Sport

DEFRA – Department for Environment, Food and Rural Affairs

DETR – Department of the Environment, Transport and the Regions (Note: DETR ceased to exist after the 2001 General Election. Its responsibilities were split largely between DEFRA and DTLR.)

DfEE – Department for Education and Employment (Note: DfEE ceased to exist after the 2001 General Election. Its responsibilities were split largely between the Department for Education and Skills and the Department for Work and Pensions.)

DfES – Department for Education and Skills

DFID – Department for International Development

DG ENV – Directorate General, Environment, at the European Commission

Disruptive innovation – Represents a transition to a new technology or a new paradigm. Often results in changing the way people think about the product, process or institution, in developing new characteristics that are subsequently expected by users, and in changing the leadership in the affected industry.

DJSGI – Dow Jones Sustainability Group Index

DSS – Department of Social Security (Note: DSS ceased to exist after the 2001 General Election. Its responsibilities were largely taken over by the Department for Work and Pensions.)

DTI – Department of Trade and Industry

DTLR – Department for Transport, Local Government and the Regions

EC – Commission of the European Union

EEBPP – Energy Efficiency Best Practice Programme

EIRIS – Ethical Investment Research Service

Elasticity of demand – Economic term relating percentage change in demand to a percentage change in some determining variable, typically income or price. Elasticities are estimated from empirical data, and can only be applied with any real confidence within the range of the data used for the estimation.

EMDA – East Midlands Development Agency

Environmental productivity – Ratio of economic output to environmental outputs.

EST – Energy Saving Trust

Externalities – Opportunity costs not fully accounted for in the price and market system, resulting in market failure with associated consequences for welfare.

Factors of production – The labour, capital, resource and technological inputs that combine together to produce output.

FCO – Foreign and Commonwealth Office

FTSE4Good – Index for socially responsible investment, designed by FTSE.

GDP – Gross Domestic Product

GO – Regional Government Office

GRI – Global Reporting Initiative

HANPP – Human appropriated net primary production

HEES – Home Energy Efficiency Scheme

ICCEPT – Imperial College Centre for Energy Policy and Technology

Incremental innovation – Small and gradual innovations in existing institutions, ideas, products or processes.

Institutional innovation – Innovations in the way organisations operate, or the creation of entirely new organisations.

IPCC – Intergovernmental Panel on Climate Change

IPR – Intellectual Property Right

IRS – Integrated Regional Strategy

JEMU – Joint Environmental Markets Unit

Labour productivity – Output produced per unit of labour (typically per worker or per hour worked).

LGA – Local Government Association

Liberalisation – Occurred in the energy utilities over 15 years from the mid-1980s onwards and entailed the privatisation of gas, electricity and coal industries and a gradual increase in the level of competition.

Market failure – Used by economists to describe the situation where the unconstrained operation of markets leads to a situation in which society is less well-off than it should be, using some objective measure. An attempt to rectify the failure is usually made through some form of Government intervention, such as regulation, economic instruments or some other policy tool.

MFA – Material Flow Analysis

MIT – Massachusetts Institute of Technology

NAO – National Audit Office

Natural resources – Includes non-renewable or stock resources such as minerals, land and fossil fuels used as energy resources, as well as renewable resources such as water and biological resources. Can also be extended to cover pollution sinks, such as the role of the atmosphere in absorbing greenhouse gas emissions, and of the land in absorbing landfill.

NFFO – Non Fossil Fuel Obligation

NGO – Non-Governmental Organisation

NMSI – National Museum for Science and Industry

NTO – National Training Organisation

NWDA – North West Regional Development Agency

NWRA – North West Regional Assembly

OECD – Organisation for Economic Co-operation and Development

OFR – Operating and Financial Review

OGC – Office of Government Commerce

ONS – Office for National Statistics

Opportunity cost – The value of that which must be given up to acquire or achieve something.

PBR – Pre-Budget Report

PIOT – Physical Input-Output Table

PIU – Performance and Innovation Unit

POST – Parliamentary Office of Science and Technology

Productive efficiency – Achieved when output of the economy being produced at the lowest cost.

Pull mechanisms – Policies designed to increase the private returns to firms for developing successful technologies, hence "pulling" them into the market.

Push mechanisms – Refers to mechanisms such as tax credits on research and development projects, or the direct spending by government to kick start various projects, which can "push" forward the development of new technologies.

RA – Regional Assembly

RCEP – Royal Commission on Environmental Pollution

RDA – Regional Development Agency

Resource productivity – Measures the ratio of economic output to natural resource inputs and thus the efficiency with which we use energy and materials in power generation, manufacturing, services and households. If the definition of natural resources is extended to cover pollution sinks, resource productivity can also subsume environmental productivity.

RO – Regional Observatories

ROCs – Renewables Obligation Certificates

RPG – Regional Planning Guidance

SBS – Small Business Service

Social innovation – Pervasive change in societal attitudes or norms.

Stakeholders – Organisations that have a vested interest in the work carried out in the project. Stakeholders are organised into three levels: primary stakeholders (people and organisations directly affected by outcomes of the project), secondary stakeholders (people and organisations who can influence the outcome of the project) and tertiary stakeholders (organisations that have an

interest in, but no direct influence on, the work carried out in the project).

Strategy – The ways of meeting the challenge set out in the framework.

Strong sustainability – Asserts that many environmental services are both "essential and non-substitutable". One definition of strong sustainability therefore states that not only should the overall capital stock grow over time, but that the natural capital stock should also grow (or at least be maintained) over time.

Sustainable development – Development that meets the needs of current generations without reducing the ability of future generations to meet their needs. The concept of sustainable development integrates the three conventionally separate domains of economic, environmental and social policy.

Technological innovation – The development and commercialisation of new products and processes.

TMR – Total Material Requirement

Total Factor Productivity (TFP) – Productivity of combined inputs used to generate gross output (also known as Multi-Factor Productivity).

Trend rate of growth – Long-term growth rate or, more specifically, the level of economic growth of an economy that is sustainable over the long term, without any tendency for the rate of inflation to rise or fall.

TUSDAC – Trade Union Sustainable Development Advisory Committee

UNFCCC – United Nations Framework Convention on Climate Change

Weak sustainability – Assumes that natural, physical and human capital are all substitutes, so that only the aggregate level of capital is important.

Welfare – Includes all of the relevant costs and benefits – economic, social and environmental.

WRAP – Waste and Resources Action Programme

WSSD – World Summit on Sustainable Development

ANNEX M: REFERENCES

ACBE, "Resource Productivity, Waste Minimisation and the Landfill Tax" (2001), available at http://www.defra.gov.uk/environment/acbe/landfill/index.htm.

ACCPE, "Choosing Green – Towards More Sustainable Goods and Services", first report (2000), available at http://www.defra.gov.uk/environment/consumerprod/accpe/report01/index.htm.

Anderson, D, "Resource Productivity: A Comment", Imperial College (2001).

Anderson, D, Clark, C, Foxon, T, Gross, R and Jacobs, M, "Innovation and the Environment: Challenges and Policy Options for the UK", Imperial College (2001).

Ashford, NA, "An Innovation-Based Strategy for a Sustainable Environment", in Hemmelskamp, J, Rennings, K and Leone, F (eds.), *Innovation Oriented Environmental Regulation*, Heidelberg: Physica-Verlag (2000).

Ayres, RU, "Resources, Scarcity, Growth and the Environment", Centre for the Management of Environmental Resources, INSEAD (2001).

Berkhout, F, "Aggregate Resource Efficiency: A Review of the Evidence", in Vellinga, P, Berkhout, F, and Gupta, J (eds.), *Managing a Material World: Perspectives in Industrial Ecology*, London: Kluwer Academic (1998).

Bleischwitz, R, "Rethinking Productivity: Why has Productivity Focused on Labour Instead of Natural Resources", Environmental and Resource Economics (2000).

Borrus, M and Stowsky, J, "Technology Policy and Economic Growth", Chapter 2 in Branscomb, LM and Keller, JH (eds.), *Investing in Innovation: Creating a Research and Innovation Policy that Works*, Cambridge MA: MIT Press (1999).

Branscomb, L and Auerswald, P, "Taking Technical Risks: How Innovators, Executives, and Investors Manage High-Tech Risks", Cambridge, MA: MIT Press (2001).

Brooks, H and Randazzese, L, "University-Industry Relations: The Next Four Years and Beyond", Chapter 14 in Branscomb, LM and Keller, JH (eds.), *Investing in Innovation: Creating a Research and Innovation Policy that Works*, Cambridge MA: MIT Press (1999).

Burningham, K and Thrush, D, "The environmental concerns of disadvantaged groups", University of Surrey for Joseph Rowntree Foundation (2001).

Butter, FAG den and Hofkes, MW, "Endogenous technology and environmental quality in economic models", International Journal of Technology and Management (2001).

Christensen, C, "The Innovator's Dilemma", New York: HarperBusiness (2000).

Commission of the European Union, "Commission Interpretative Document on the Community law applicable to public procurement, and the possibilities for integrating environmental considerations into public procurement", COM (2001), 274.

Commission of the European Union, "Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste" (1999), available at http://www.europa.eu.int/eur-lex/en/lif/dat/1999/en_399L0031.html.

Commission of the European Union, "Green Paper on Innovation", COM (1995) 688 final.

Commission of the European Union, "Innovation in a Knowledge-Driven Economy", COM (2000) 567 final.

Commission of the European Union, "European Trend Chart on Innovation Country Report: United Kingdom" (2000a), available at http://trendchart.cordis.lu/Reports/index.cfm?

Council for the Protection of Rural England (CPRE), "Rocky Logic: The Role of Aggregates in the UK Economy" (1999).

Crafts, N, Presentation to the IEA 16th State of the Economy Conference (2001).

Crafts, N and O'Mahony, M, "A Perspective on UK Productivity Performance" (2001).

CSERGE, "Externalities of landfill and incineration", report to the Department of the Environment (1993).

DEFRA, "Carbon Intensive Industry in the UK – A Paper for TUSDAC" (2001).

DETR, "A Better Quality of Life – A Strategy for Sustainable Development for the United Kingdom", CM 4345 (1999), available at http://www.defra.gov.uk/environment/sustainable/index.htm.

DETR, "Quality of Life Counts: Indicators for a Strategy for Sustainable Development for the United Kingdom: a Baseline Assessment" (1999a), available at http://www.sustainable-development.gov.uk/indicators/headline/h2.htm.

DETR, "Achieving a better quality of life – Review of progress towards a sustainable development: Government Annual Report 2000" (2000).

DETR, "Building A Better Quality of Life – A Strategy for Sustainable Construction" (2000a).

DETR, "Climate Change – The UK Programme", CM 4913 (2000b).

DETR, "General Guidelines on Environmental Reporting – Consultation Draft" (2000c), available at http://www.defra.gov.uk/environment/envrp/index.htm.

DETR, "Transport 2010 – The 10 Year Plan" (2000d).

DETR, "Waste Strategy 2000 for England and Wales (Part 1 and 2)", CM 4693 (2000e), available at http://www.defra.gov.uk/environment/waste/strategy/cm4693/index.htm.

DETR, "The UK Fuel Poverty Strategy – A Consultation Paper" (2001).

DfEE, "Building a Stronger Network: Developing the Role of National Training Organisations" (2000), also available at http://www.dfes.gov.uk/consultations/archive/archive1.cfm?CONID=46.

DfES, "Meeting the Sector Skills and Productivity Challenge" (2001).

DFID, "Eliminating World Poverty: Making Globalisation Work for the Poor: White Paper on International Development", CM 5006 (2000).

DSS, "Opportunity for All – Tackling Poverty and Social Exclusion – First Annual Report 1999", CM 4445 (1999).

DTI, "Energy Projections for the UK", Energy Paper 68 (2000).

DTI, "Excellence and Opportunity, a science and innovation policy for the 21st century" (2000a).

DTI, "Opportunity for All in a World of Change" (2001).

East Midlands Regional Assembly, "England's East Midlands Integrated Regional Strategy – Our Sustainable Development Framework" (2000).

EIRIS, "Does ethical investment pay?" (1999).

Ekins, P and Linstead, C, "Mass Balance UK: Mapping UK Resource and Material Flows" (2001).

Elbasha, EH and Roe, TL, "On Endogenous Growth: The Implications of Environmental Externalities", Journal of Environmental Economics and Management (1996).

ENDS, "Environment Daily 1009", 14 June 2001.

Energy Saving Trust, "Energy and Environmental Support to UK SMEs" (2001).

Environment Agency, "State of the Environment Report for London, 2001" (2001), available at http://www.environment-agency.gov.uk/regions/thames/110327/?lang=_e&region=thames.

Fine, Professor B, "Endogenous Growth Theory: A Critical Assessment", SOAS Working Paper Number 80 (1997).

Foster, R, "Innovation: The Attacker's Advantage", New York: Summit Books (1986).

Grimaud, A, "Pollution Permits and Sustainable Growth in a Schumpeterian Model", Journal of Environmental Economics and Management (1999).

Hawken, P, Lovins, AB and Lovins, LH, "Natural Capitalism – The Next Industrial Revolution", Earthscan (1999).

Hession, M, "Working Paper: European Policy Review. Legislation Relevant to Energy and Resource Productivity", Imperial College (2001).

HM Treasury, "Tax Measures to Help the Environment", News Release, 2 July 1997 (1997).

HM Treasury, " 'The Green Book' – Appraisal and Evaluation in Central Government" (1997a), available at http://www.hm-treasury.gov.uk/guid.html.

HM Treasury, "Government Accounting 2000: A Guide to Accounting and Financial Procedures for the use of Government Departments" (2000).

HM Treasury, "Productivity in the UK: The Evidence and the Government's Approach" (2000a).

HM Treasury, "Budget 2001" (2001).

HM Treasury, "Productivity in the UK: Enterprise and the Productivity Challenge" (2001a).

HM Treasury, "Productivity in the UK: Progress Towards a Productive Economy" (2001b).

HM Treasury and DETR, "Environmental Issues in Purchasing", guidance note (2000).

HM Treasury and Inland Revenue, "Increasing Innovation – A Consultation Document" (2001).

Hogg, D, "Waste in the Resource Productivity Framework", private report for PIU, Eunomia Research and Consulting (2001).

IPCC, "Climate Change 2001: Impacts, Adaptation and Vulnerability – IPCC Working Group 2 Summary for Policy-Makers" (2001).

IPCC, "Climate Change 2001: Mitigation – IPCC Working Group 3 Summary for Policy-Makers" (2001a).

Krautkraemer, JA, "Nonrenewable Resource Scarcity", Journal of Economic Literature, Volume XXXVI (1998).

Mabey N, Hall, S, Smith, C and Gupta, S, "Argument in the Greenhouse – The International Economics of Controlling Global Warming", Routledge (1997).

Margolis, R and Kammen, D, "Evidence of under-investment in energy r&d in the United States and the impact of Federal policy", Energy Policy 27 (1999).

Moffatt, I, Hanley, N, Allen, S and Fundingsland, M, "Sustainable Prosperity: Measuring Resource Efficiency" Report to DETR (2001).

Murray, R, "Creating Wealth from Waste", DEMOS (1999).

Myners, P, "Myners Review of Institutional Investment: Final Report" (2001).

OECD, "Technological Change, Public Policy and the Environment" (2000).

OECD, "OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity Growth" (2001).

OECD, "Policy Brief – A New Strategy for the Environment" (2001a).

OECD, "The New Economy: Beyond the Hype", Final Report on the OECD Growth Project (2001b).

ONS, "Annual Abstract of Statistics" (2001).

ONS, "UK National Accounts – The Blue Book" (2001), available at http://www.statistics.gov.uk/products/p1143.asp.

Pearce, D, "Resource Productivity: An Outsider's View of the State of Play and What Might Need to be Done", UCL (2001).

Pearce, D and Palmer, C, "Public and Private Spending for Environmental Protection: A Cross-Country Policy Analysis", UCL (2001).

PIU, "Rights of Exchange: Social, Health, Environmental and Trade Objectives on the Global Stage" (2000), available at http://www.cabinet-office.gov.uk/innovation/reports/reports.shtml.

PIU, "Workforce Development" project (2001), papers available at http://www.cabinet-office.gov.uk/innovation/reports/reports.shtml.

Porter, M and van der Linde, C, "Green and Competitive: Ending the Stalemate", Harvard Business Review vol 73 (1995).

POST, "Cleaning Up? Stimulation Innovation in Environmental Technology", Report Number 136 (2000).

Rasmussen, Poul Nyrup (Prime Minister of Denmark), "Towards a Sustainable Future", OECD Observer (2001).

Romer, D, "Advanced Macroeconomics", McGraw Hill (1998).

Rothenberg, J, "Economic Perspectives on Time Comparisons: An Evaluation of Time Discounting", in Choucri, N (ed.), *Global Accord: Environmental Challenges and International Responses*, MIT Press, Cambridge (1993).

Royal Commission on Environmental Pollution (RCEP), "Energy – the Changing Climate", CM 4794 (2000).

Smith, A, "An Inquiry into the Nature and Causes of the Wealth of Nations", first published 1776, reprinted by Clarendon Press (1976).

Smulders, S, "Economic Growth and Environmental Quality", in *Principles of Environmental and Resource Economics*, Edward Elgar (2000).

UNFCCC, "Kyoto Protocol to the Framework Convention on Climate Change" (1997).

US Environment Protection Agency (EPA), "Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste" (1998).

Utterback, J, "Mastering the Dynamics of Innovation", Boston: Harvard Business School Press (1996).

Voisey, H and Hewett, C, "Reconciling Social and Environmental Concerns", Overview paper for the Joseph Rowntree Foundation RESC Research Programme (1999).

Wallis, P, "Changing Course to Responsible Fisheries", OECD Observer (2001).

WRAP (Waste and Resources Action Programme), "The WRAP Business Plan – creating markets for recycled resources" (2001), available at http://www.wrap.org.uk.

Performance and Innovation Unit
Cabinet Office
Fourth Floor
Admiralty Arch
The Mall
London SW1A 2WH
Telephone 020 7276 1416
Fax 020 7276 1407
E-mail piu@cabinet-office.x.gsi.gov.uk
Web www.cabinet-office.gov.uk/innovation

Publication date 20 November 2001

This report is printed on Revive Matt material. It is made from 75% recycled de-inked post-consumer waste, is totally chlorine free and is fully recyclable.

Ref: CABI J01-8768/0111/D16