

SUMMARY

1. Access to abundant and instantly available energy underlies our entire way of life, yet its impact on the environment is growing. This poses a radical challenge for the UK; a challenge that cannot be met successfully unless the government's energy policies and its environmental policies are coherent. A sustainable energy policy for the UK should protect the interests of generations to come, but it must also seek to achieve social justice, a higher quality of life and industrial competitiveness today. Achieving the right balance is formidably difficult; current policies do not strike it.

2. All energy supplies have substantial effects on the environment. Some have impacts on human health and they all change the natural world to some extent. Damaging air pollutants from fossil fuels, large, intrusive wind farms in upland scenery, radioactive emissions from the reprocessing of spent nuclear fuel and the destruction of woodlands to supply cooking fuel and warmth in poor countries are all well known examples of this broad range of concerns.

CLIMATE CHANGE – THE NEED FOR GLOBAL AGREEMENT

3. One effect of energy supply has now come to assume special importance, though it was barely in the consciousness of politicians or the public 20 years ago. This is human-induced climate change which is threatening to impose very significant shifts in temperatures, rainfall, extremes of weather and sea levels in this century and those that follow. The principal cause is that the concentration of carbon dioxide in the atmosphere has been rising, mainly because of humanity's growing use of fossil fuels, and trapping more solar warmth. The concentration of carbon dioxide is already higher than at any time for millions of years and we seem to be experiencing the first effects.

4. Some human-induced climate change now seems inevitable. There will, therefore, be a need for adaptation by nations and communities. But the larger challenge is to halt the steady rise in the concentrations of carbon dioxide and other greenhouse gases, limiting further change and reducing the risks of catastrophic alterations in climate. Given the present state of knowledge of the climate system, we support the proposal that an atmospheric carbon dioxide concentration of 550 parts per million by volume (ppmv) – approximately double the pre-industrial level – should be regarded as an upper limit that should not be exceeded. The current concentration is some 370 ppmv.

5. Fossil fuels are finite, so people will eventually have to stop consuming them – but if they were all burnt during the course of this century and the next the resulting build up of carbon dioxide would go well above 550 ppmv and would be likely to lead to dangerous and destructive climate change. Even if the global use of coal, oil and gas was prevented from rising and held at current levels the climate would change markedly. To limit the damage beyond that already in train, large reductions in global emissions will be necessary during this century and the next. Strong and effective action has to start immediately.

6. Countering the threat of major changes in climate is a task for the entire world community. Developing nations produce much less carbon dioxide *per capita* than developed countries like the UK. But the developing world's consumption of fossil fuels is rising rapidly as it industrialises and living standards rise. It seems highly likely that its emissions will overtake the combined emissions of the developed countries within a few decades. International agreement on a means of limiting each country's emissions is needed, so that the global total is kept to a level which prevents intolerable and dangerous climate change.

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7. The most promising, and just, basis for securing long-term agreement is to allocate emission rights to nations on a *per capita* basis – enshrining the idea that every human is entitled to release into the atmosphere the same quantity of greenhouse gases. But because of the very wide differences between *per capita* emission levels around the world, and because current global emissions are already above safe levels, there will have to be an adjustment period covering several decades in which nations' quotas converge on the same *per capita* level. This is the principle of contraction and convergence, which we support.

8. International trading in emissions quotas could play a crucial role in enabling such an agreement to be obtained and adhered to, as could partnership agreements under which developed nations help to achieve clean development in industrialising countries. Nations which found it costly and difficult to make the required emission reductions would be willing to purchase quota at a negotiated price from states which found it relatively cheap to emit less than their quota.

THE UK'S ROLE

9. For the UK, an international agreement along these lines which prevented carbon dioxide concentrations in the atmosphere from exceeding 550 ppmv and achieved convergence by 2050 could imply a reduction of 60% from current annual carbon dioxide emissions by 2050 and perhaps of 80% by 2100. These are massive changes. But the government should implement short, medium and long term strategies which are sufficiently coherent and effective to achieve these reductions. Action at home would help the UK, as part of the European Union, to argue strongly for significant action by other nations; only if the majority of nations act can there be any hope of stabilising carbon dioxide concentrations at a tolerable level.

10. Major benefits, unrelated to reducing climate change, would flow from policies to reduce our use of fossil fuels. Among the benefits are a reduction in the air pollution which harms human health and causes acid rain and photochemical smogs and a reduction in the congestion, noise and environmental degradation caused by rising levels of road traffic. If the package of policies included raising the very low levels of energy efficiency in UK housing, this could be tied to urban regeneration and the elimination of fuel poverty.

11. UK governments have played an important and constructive role in obtaining, first, general recognition that climate change is an issue of fundamental importance and, second, commitments from the developed countries to cut their rising emissions of greenhouse gases. Reaching agreement on further necessary actions by the entire world community will probably be much harder, and take much longer, without continued leadership from the UK and other European nations.

12. International leadership must have a firm basis in effective and appropriate national policies. The UK has recently made substantial reductions in its greenhouse gas emissions, and has referred to these while exhorting other nations to act. However, the amount of energy the UK uses is still increasing and the factors that have led to emission reductions over the last decade are largely coincidental. Chief among these is the substitution of gas for coal as fuel in power stations. This will contribute to further reductions in this decade but, at this stage, it looks as if making further substantial cuts in carbon dioxide emissions will become much more difficult for the UK after 2010.

13. The UK is therefore poorly prepared, as yet, to face the long-term challenge of reducing emissions from coal, oil and gas to far below present levels. The government's goal of a 20% reduction in carbon dioxide emissions by 2010 (compared to their 1990 level) is much more ambitious than the UK's international legal obligation under the UN's Kyoto Protocol of a 12.5% reduction in greenhouse gas emissions. If the former can be achieved, this will represent

valuable and world-beating progress. The government has now produced a draft climate change programme. This goes beyond meeting the Kyoto obligation, but it is not yet sufficient to achieve a 20% carbon dioxide reduction by 2010. Looking further ahead, a programme for more radical changes will be required.

14. We have considered what needs to be done in the longer term. We have sought to relate that directly to actions that can and should be taken by the government and by other parties in the UK now. We have examined the scope for reducing the demand for energy. We have assessed the extent to which new and renewable energy sources – which produce either no carbon dioxide, or far less than existing fossil fuel technologies – can substitute for coal, oil and gas. We have considered the wider economic, social and environmental aspects of reducing demand and developing alternatives to fossil fuels, as well as their technical feasibility.

LOCKING UP CARBON DIOXIDE

15. We have also considered other approaches to the problem which involve locking the extra carbon dioxide produced by humanity away from the atmosphere. Trees and other vegetation take up carbon dioxide when they grow and release it when they burn or rot, so wise management of the Earth's forests is desirable. Globally, forest re-growth could only compensate for a small part of the rising carbon dioxide emissions; simplistic suggestions that climate change can be prevented by planting trees are wide of the mark. The priority should be to prevent deforestation making things worse, while at the same time meeting other essential needs for land in developing countries.

16. The land area of the UK is too small for tree planting to make a significant contribution to removing its own fossil fuel emissions from the atmosphere. The UK should, however, conserve its existing forests and seize opportunities to expand them for the sake of protecting wildlife, enhancing landscapes and improving amenity. It must also conserve other major carbon sinks, particularly soils and peat bogs, in ways which prevent them from becoming significant carbon sources.

17. The oceans are a huge reservoir for carbon. But not enough is known about their internal processes to be sure that either stimulating the growth of microscopic marine plants or injecting liquid carbon dioxide directly into seawater would be an effective way of keeping greenhouse gases out of the atmosphere. Either might have major unintended consequences, particularly for marine life.

18. There is considerable potential for disposing of carbon dioxide in deep geological strata with minimal environmental impact. If the present high cost of removing carbon dioxide from emissions were regarded as acceptable, or could be reduced, removal and disposal might make a significant contribution to reducing emissions. Disposal in geological formations beneath the sea-bed may be safer and more secure than in those below dry land. But this approach can only be applied to emissions from large installations such as power stations, not to the larger share of emissions which come from vehicles and homes. Further research into the safety of this disposal technology is required. If it proves safe and cost-effective then a substantial proportion of UK electricity could continue to be produced by fossil-fuel burning plant with capture and isolation of the carbon dioxide produced. But reductions in the demand for energy and the deployment of non-fossil fuel energy sources have the leading role to play in reducing emissions over the coming decades.

REDUCING ENERGY USE

19. The demand for energy in the UK has been rising steadily. This increase is linked to the growing output of goods and services associated with economic growth, increasing travel, the rising number of households and the gradual increase in population. Energy consumption has risen more slowly than economic activity (as measured by gross domestic product), reflecting the tendency of organisations and individuals to find ways of using energy more efficiently.

20. But there is ample opportunity for further, large efficiency improvements in the use of energy by manufacturing industry, commercial and public services, households and transport. The scope for improvements in buildings of all kinds, but especially housing, is particularly large. Every house should have an energy label and energy efficiency standards for new buildings, as set out in the building regulations, should be drastically improved over the next few years. The need for improvements in transport is particularly pressing, given the rapid growth in this sector's energy consumption.

21. It should be possible to reduce the UK's overall energy consumption without damaging its international competitiveness or causing hardship. Such a reduction would make a major contribution to achieving long-term reductions in carbon dioxide emissions.

22. To bring this about will require government to give much higher priority to energy efficiency, a change in public attitudes with people linking their own day to day use of energy with fossil fuel consumption and the threat of climate change, and a new cultural and institutional framework within which individuals will feel that they can make a difference. To these ends, government should build on its existing energy efficiency policies and campaigns and introduce new ones. Further incentives are required, as are new and strengthened regulations.

A CARBON TAX

23. The prices consumers pay for fossil fuels do not, for the most part, reflect the harm their use is doing and will continue to do as the impacts of increasing climate change make themselves felt. Fossil fuel and electricity prices in the UK have, for the most part, been falling during the last decade, reducing the incentives to improve energy efficiency. This is partly a reflection of global price shifts, and partly the result of government policy in privatising major energy suppliers and then regulating the liberalised markets. The government now plans to introduce an energy tax called the climate change levy to stimulate efficiency improvements and reduce energy consumption. Some energy sources and some consumers will be exempted, either partially or entirely. Households will not have to pay the tax, on the grounds that if they did this would increase fuel poverty. Some of the revenues raised will be used to promote energy efficiency improvements and alternatives to fossil fuels.

24. We welcome this approach but we favour a general carbon tax based on the quantity of carbon dioxide emitted per unit of energy supplied. It should be applied upstream, when fossil fuels are first purchased. This would give producers, distributors and consumers of energy an incentive to switch to sources which produced fewer emissions. It would lead to higher energy prices downstream, stimulating efficiency improvements and reducing consumption. Other environmentally harmful aspects of energy supply and use are already covered, to some extent, by regulation and taxation. Emissions of carbon dioxide are not; hence the need for a carbon tax.

25. We accept that such a tax would, without mitigation, tend to increase fuel poverty. This ought to be eradicated; we find it unacceptable that in a relatively wealthy nation like the UK, millions of vulnerable people cannot afford adequate warmth in their homes. The first call on the revenues from a carbon tax, which we envisage being introduced initially at a relatively low rate, would be to prevent any overall increase in fuel poverty and to reduce it further. This should be done through increases in benefits and through an enhanced programme to improve radically the energy efficiency of the worst of the UK housing stock.

26. Some of the carbon tax revenues should fund other measures for reducing emissions, such as subsidies and tax relief for energy efficiency improvements and research and development of low carbon and carbon free energy sources. The remaining revenues should be used to offset the adverse effects of the tax on the international competitiveness of UK commerce and industry; reducing taxes on employment is one option.

ALTERNATIVE ENERGY SOURCES

27. Many sources of energy have emerged as potential alternatives to fossil fuels. Exploiting these also gives rise to a wide range of impacts on the environment. Such impacts ought to be taken into account from the outset in deciding what role alternative energy sources can play. Some alternatives to fossil fuels are associated with indirect emissions of carbon dioxide; an example would be the emissions from road transport taking energy crops from fields to power stations. However, the overall emissions from the alternative energy sources are much lower than those of fossil fuels.

28. The strong growth in air travel and road traffic indicates that much more needs to be done to control their rising emissions. But aircraft and road vehicles are likely to continue to depend on fossil fuels for some decades to come. Some reduction in carbon dioxide emissions from road transport can be achieved by reformulating oil and gas into hydrogen-rich fuels which can be used in on-board fuel cells powering electric motors. In the longer term, much larger reductions in transport emissions might be achieved by switching to hydrogen produced from water using non-fossil fuel energy.

29. The large-scale non-carbon energy sources that are already well established and available in large quantities in the UK are nuclear power and hydro power, both of which supply only electricity. There is only a limited potential for further large-scale exploitation of hydro power in the UK and environmental concerns may rule out further major schemes. Further growth in the number of small-scale hydro schemes is possible, but not to the extent that it could make a substantial contribution to UK energy needs.

NUCLEAR POWER

30. Nuclear power is a significant source of carbon-free energy for the UK, having enjoyed four decades of extensive state support in research, development and operation. But unless new plant is built, nuclear power will almost have ceased by 2020. New nuclear power stations should not be built until the problem of managing nuclear waste has been solved to the satisfaction both of the scientific community and the general public. Irrespective of the future role of nuclear power, an effective long-term repository needs to be provided to accommodate the wastes that already exist.

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31. Nuclear power could continue to play an important role in reducing UK greenhouse gas emissions. We do not, however, accept the arguments of those who hold that it is indispensable. We do not believe public opinion will permit the construction of new nuclear power stations unless they are part of a strategy which delivers radical improvements in energy efficiency and an equal opportunity for the deployment of other alternatives to fossil fuels which can compete in terms of cost and reduced environmental impacts. The procedures for weighing up these issues will need to allow for debate of a high standard, and at the same time be capable of articulating deeply held values and beliefs. We have suggested in our previous report, on environmental standards, how that might be achieved.

32. A priority for government should be to set out a programme demonstrating the new non-fossil fuel resources (which may or may not include nuclear power) and/or the reductions in energy demand that could compensate for the expected closure of almost all existing UK nuclear plant over the next two decades. This needs to be done within the next five years, because of the long period required to implement a programme on this scale. If the nuclear plants were replaced by fossil fuel power stations without carbon dioxide capture and isolation then all of the emission reductions achieved so far would be undone. If renewables and demand reduction cannot be brought forward on the scale required, and if capture and isolation of carbon dioxide proves unsafe or prohibitively expensive, the case for building new nuclear stations will be strengthened.

33. There is no foreseeable prospect of some magic source of almost unlimited energy with negligible environmental impact. Nuclear fusion has sometimes been advocated as that, but it is still at the research stage and a commercial-scale demonstration plant seems unlikely to be constructed before 2050. Its environmental impact, as well as its economic viability, have yet to be clarified.

TIDES, WINDS, WAVES AND SUNSHINE

34. Tidal barrages could generate large quantities of electricity on a predictable but intermittent basis. There are none operating in the UK but the technology is proven. They would be expensive to construct and are likely to have major impacts on the wildlife and ecology of estuaries. Their economic viability might be increased if they formed part of barrages built across estuaries to prevent flooding from rising sea levels.

35. The UK has abundant wind energy distributed across much of its landmass. The surrounding seas offer an even larger wind resource, and very large quantities of energy in the form of waves and strong tidal currents. All should be harnessed for our needs. Despite frequently overcast skies, solar energy could also make a substantial contribution to UK energy needs – through electricity-generating photovoltaic panels, solar panels which heat water for use in buildings directly and building designs which enable sunshine to warm and light interiors.

NON-FOSSIL FUELS

36. Alternative fuels to coal, oil and gas can also make a contribution to reducing the UK's overall carbon dioxide emissions. The combustion of agricultural and forestry wastes, methane from waste in landfill sites and household rubbish could play a limited but worthwhile role. The growing of energy crops such as coppice willow, which are then burned or gasified and combusted to generate electricity and supply heat, could make a much larger contribution to the UK's long-term climate change strategy. They might also contribute to increasing

biodiversity and improving farmland landscapes. But this cannot be achieved without major changes to agricultural support systems. We propose that energy crops should receive the same level of support as other crops, but with improved environmental safeguards.

37. Some of the technologies needed to harness these renewable energy resources are now well established. Their total contribution is still minor, but the number of installations has been growing fast. Onshore wind turbines are an example. Wave power devices and undersea turbines turned by tidal streams have great potential but are still at the earliest stages of development with relatively little government support.

SUPPORTING RENEWABLE ENERGY

38. The UK's supply of energy from these non-fossil fuel, non-nuclear sources has more than doubled in the past decade, a welcome increase. But considering the enormous potential of UK renewable energy resources, it has been slow to make progress; several other European nations have achieved more. Irrespective of global warming, renewable energy resources will have a growing role to play around the world and there are likely to be major export opportunities which the UK will be unable to take advantage of unless its domestic renewables industry expands from its current small size.

39. We welcome the government's recent commitments on expanding renewable energy, but this sector needs further support. There cannot, however, be some central master plan for new energy sources. It is impossible to predict 50, or even 15, years ahead how each area of technology will develop, and how competitive it will become in cost and in other terms. Policies should continue to be based on facilitating and stimulating the emergence of new technologies and reducing their environmental impacts. A carbon tax would help, by enabling renewable energy sources to compete with fossil fuels.

40. It makes sense to provide guarantees or subsidies for those technologies which are proven and closest to providing energy at open market prices. Experience has shown that the resulting mass deployment makes them more competitive still. But there is also a strong need for direct government support for research and development on some of the least developed technologies which offer great potential but are some way from being competitive, such as wave power, tidal stream turbines and photovoltaic cells. In coming decades the government will need carefully to monitor novel energy technologies which can reduce carbon dioxide emissions, supporting further research and development in those that are most relevant to the UK's circumstances.

41. Because renewable energy installations tend to be relatively small, there will need to be more of them and they are likely to be more dispersed. Plans to construct wind farms in scenic upland areas have run into serious, and understandable, opposition. More effective use must be made of the land use planning system to help the deployment of such energy systems whilst respecting people's legitimate wishes to protect cherished landscapes and wildlife. A more strategic approach to selecting sites is required, at national and regional levels, in development plans and offshore. This process would be assisted if programmes to develop renewable energy systems were subject to strategic environmental assessment. Every community should review its impact on the environment in terms of demands for energy, and the ways in which they can be met. Promoters of schemes should establish a dialogue with the local community at an early stage.

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COMBINED HEAT AND POWER

42. For far too long, policies have favoured the generation of electricity in ways that waste vast quantities of heat – heat that could be used to warm buildings. The more recent promotion of renewable energy sources has focussed almost entirely on electricity rather than heat output.

43. Regulatory and planning policies should encourage the widest possible adoption of combined heat and power (CHP) technology in urban locations to supply heat. Local communities should be encouraged to establish heating networks serving entire estates or urban districts, supplied by CHP. Gas-fired CHP plant will reduce carbon dioxide emissions by making more efficient use of energy, even though it will for the time being reinforce the role in the UK energy system of a fossil fuel. The expansion of CHP generating heat for district heating systems could provide a growing market for renewable fuels such as energy crops. Electrically powered heat pumps, which can utilise the abundant low-grade heat in surface and ground waters and in municipal wastewater can also provide warmth and hot water for buildings via heat networks, substantially reducing carbon dioxide emissions.

CHANGING THE GRID

44. The relatively small size of renewable energy plants generating electricity and local CHP plants does not fit easily with an electricity distribution and transmission network based on massive generators and highly centralised control. The national grid and the regional distribution systems need to become more favourable to small and very small environmentally friendly generators which sometimes need to import electricity. Regulatory policies will need to promote, and must not inhibit, this development. The government and the electricity supply industry must together devise a system which can handle a growing quantity of this embedded generation securely and efficiently.

45. As the proportion of electricity supplied by wind, waves, tides and sunshine increases, the intermittency of these sources will pose growing problems in matching supply with demand. Electricity cannot currently be stored in very large quantities. If the UK is to rely heavily on these intermittent resources to reduce emissions, then it will either need massive but little used reserve generating capacity (consisting of fossil fuel or renewable fuel plant), or large new energy stores or novel energy carriers. Hydrogen produced using electricity and then consumed in power-generating fuel cells is one possible carrier. The costs and complexities associated with these approaches could form a substantial barrier to the major deployment of intermittent renewables. Government must stimulate research into solving the problems that large-scale intermittency and embedded generation would pose to the electricity supply system as a matter of urgency.

ALTERNATIVE SCENARIOS

46. We have drawn up four scenarios for energy supply and demand in the UK, on the assumption that carbon dioxide emissions from fossil fuel combustion must be reduced by 60% from their 1998 level in 2050. We have developed these scenarios in numerical terms, because figures impose some discipline even though they are only as good as the assumptions on which they are based. The scenarios assume various degrees of reduction in energy demand, all of them substantial, and various mixes and levels of renewable energy resources. Two of the scenarios assume a large contribution from nuclear power or an equivalent electrical output from large, fossil fuel-burning power stations with carbon dioxide capture and isolation in geological strata. The other two have neither nuclear power nor carbon dioxide capture and isolation.

47. The conclusion that emerges is that, unless energy demand is curbed to a significant degree, making substantial reductions in UK emissions would require a massive and environmentally intrusive contribution from renewable sources augmented either by nuclear power or by fossil fuel power stations with large-scale capture and isolation of carbon dioxide.

ACTION NOW

48. Energy policies of the kind we are seeking will not emerge unless there is a thoroughgoing change of approach and change of culture within government. Some aspects of present energy policies are in conflict with the reduction of carbon dioxide emissions, and current policies aimed at reducing emissions seem likely to fall short of the goal of reducing annual carbon dioxide emissions by 20% between 1990 and 2010. The government's current arrangements for making and implementing energy and environment policy are inadequate for the task which lies ahead. We propose that a Sustainable Energy Agency should be set up to provide impetus for the improvements in energy efficiency required and the necessary development and expansion of renewable energy resources.

49. There is little public awareness or acceptance of the measures needed to accomplish sustained, deep reductions in greenhouse gas emissions. The government needs to secure active support by industry, commerce, local authorities and society in general. People and organisations should be made aware of the way in which their use of fossil fuels is contributing to climate change and then be encouraged to take responsibility for their own reductions in fossil fuel consumption. But the framework in which energy and environment policies are devised must enable people to feel that if they are 'doing their bit' then so are others – including local and central government, large corporations and institutions.

50. Concerted policies for changing the UK's energy system and reducing carbon dioxide emissions need to be sustained through successive Parliaments. We propose that challenging national targets should be set for improving energy efficiency and developing new energy sources. These will need to extend beyond the timescale of current obligations on the UK under the UN's Framework Convention on Climate Change.

51. In this report we illustrate ways in which the UK could cut its carbon dioxide emissions by 60% by 2050. Achieving this will require vision, leadership, and action which begins now. Governments are seldom asked to look and to plan so far into the future; the quickening pace of change and the shrinking power of the nation state may make it increasingly difficult to do so. We emphasise that an even greater reduction in carbon dioxide emissions is likely to be required by the end of the century.

52. The enormous challenge posed by humanity's intervention in the Earth's climate, threatening generations to come, demands action on this scale. If the UK does not show it is serious about doing its part, it cannot expect other nations – least of all those which are much poorer – to do theirs.