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ENGLISH NATURE
DISCUSSION PAPER ON BIOFUELS

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1. Executive Summary

1.1 The UK has signed up to ambitious targets for renewable electricity generation, liquid biofuels production, and reductions in CO_2 emissions. Reaching these targets is likely to be very difficult, and probably impossible without a substantial contribution from biomass energy, both from crops and from organic wastes.

1.2 The UK government has already made important strategic and policy decisions on the use of biomass and biofuel crops to contribute towards UK targets on renewable energy, including the allocation of at least £350 million towards capital infrastructure for biomass electricity and heat generation. There is therefore a considerable amount of political pressure for these industries to succeed, especially the generation of energy from biomass. However there is also risk: the UK's largest biomass energy plant failed spectacularly in recent months, and Government is hesitant about lowering road fuel duty for liquid biofuels, a measure that the industry believes is essential at this stage.

1.3 At the regional and sub-regional levels, detailed assessments are currently being made of renewable energy resources, and several planning applications for biomass-fuelled power stations have been submitted, although some of these have been unsuccessful due to concerns about local emissions. Waste materials will initially power many of the smaller-scale schemes, but future generating capacity may rely largely on cultivated woody biomass crops.

1.4 Biomass and biofuel crops are an attractive proposition since they provide the opportunity of fulfilling targets on renewables, rural development and possibly biodiversity. However, renewable energy generation may still involve a significant amount of energy input in the form of fossil fuels, so it does not necessarily translate into significant CO_2 savings. Viable biomass and biofuels industries may be relatively costly to set up and sustain, if considered in terms of the economic value of CO_2 emissions saved.

1.5 Driven primarily by large-scale economic factors such as the relative profitability of different crops and land uses, the growth of these sectors could lead to significant changes in land use over which Government will have little or no control, at least at the local level. Outcomes for biodiversity are at best uncertain.

1.6 Benefits to biodiversity and water quality may be partly secured by voluntary or compulsory agri-environment measures, as well as the use of the planning system where possible to ensure that novel land uses do not harm valuable wildlife sites. Research and development will also be important in the longer term to find improved crop varieties and management systems that will increase the efficiency of the processes, as well as reducing the impact on biodiversity and water resources.

1.7 English Nature has opportunities now to influence the way in which the biomass and biofuels industries are set up, and to ensure that supply chains of both cultivated and waste materials are managed in a way that delivers biodiversity gain.

2. Background

2.1 The UK has national and international commitments to reduce greenhouse gas emissions, and increased adoption of renewable energy technologies will be part of this process, alongside policies to reduce demand. Most existing technologies offer intermittent or variable rates of supply, e.g. solar, wave and wind energy, whereas biomass and biofuel crops are amenable to transport and long-term storage, and could therefore make a valuable contribution to UK renewable energy supply. However, compared to other mainstream sources of renewable energy, biomass and biofuel crops may be a relatively inefficient way of producing usable energy per unit land area and per unit energy input. They are also likely to have significant impacts (some positive, some negative) on biodiversity, water and air quality, and rural landscapes. However, they are an attractive option for Government, since creating markets for biomass crops could provide new and/or more reliable sources of income for farmers, and retain or create employment in rural areas.

2.2 This paper assesses the policy context for the potential large-scale introduction of biomass crops in the UK, dividing it into two key issues:

- What factors are influencing how much importance Government places on biofuel/biomass crops for electricity, heat and liquid fuels, compared to other forms of energy production, and therefore how much will the UK need to grow in the short/medium/long term?

- How can we influence the achievement of these targets for biofuel/biomass crops, so that this effort contributes to sustainable development, with particular emphasis on biodiversity?

2.3 The paper discusses drivers that could influence the uptake of biomass energy crops in the UK, and sets out what English Nature's role could be in ensuring the best outcomes for wildlife conservation. A diagram summarising the drivers and indicating the way in which they interact is shown in Annex A.

3. The possible role of biomass energy crops in the UK

Policy drivers for renewable energy and energy demand management in the UK

3.1 Currently, the UK relies largely on the use of non-renewable 'fossil fuels' and nuclear energy to provide energy for industry, domestic and the commercial and public services sectors, and transport[1]. [Explanation of the footnotes can be found in the "Background Notes" section at the very end of this paper.] Supplies of fossil fuels (oil, coal and natural gas) are expected to run out during the latter half of the 21st century, there are growing concerns about the risks of relying on imported fuels, and there is compelling evidence that carbon dioxide (CO_2) emissions resulting from the burning of these fuels are contributing to climate change. The UK has international commitments through the Kyoto Protocol to reduce its CO_2 emissions, which will involve a combination of reducing demand for energy through efficiency measures and behavioural changes, and finding alternative energy sources that are not based on fossil fuels.

3.2 The Kyoto Protocol was ratified by the European Union in 2002, entering the UK into a binding commitment to reduce its greenhouse gas emissions to 12.5% below 1990 levels by the period 2008-12. However, the European Environment Agency reported in May 2003 that the European Union is slipping on its Kyoto targets, after greenhouse gas emissions increased for the second year running, caused mainly by large increases in emissions from Ireland, Portugal and Spain. The UK looks set to meet its own target, but still reported significant increases in CO_2 emissions from certain sectors e.g. residential +13%, road transportation +7% and civil aviation +36% on 1990 levels (European Environment Agency, 2003). CO_2 emissions from transport make up an increasing percentage of the UK total (19% in 1990; 23% in 2001), and look set to rise further in the future[2]. UK renewable energy generation in 2001 was more than double that in 1990, but still made up only 2.6% of electricity generation and 1.3% of total energy generation.

3.3 The 2003 Energy White Paper sets out the UK government's ambition to achieve 20% and 60% reductions in CO_2 emissions by 2020 and 2050 respectively. To achieve these ambitions, the government envisages "a fundamental long-term shift in the way energy is supplied and used. [In 2020] there will be much more local generation, in part from medium to small local/community power plant, fuelled by locally grown biomass, from locally generated waste, from local wind sources, or possibly from local wave and tidal generators. These will feed local distributed networks, which can sell excess capacity into the grid. Plant will also increasingly generate heat for local use."

3.4 The White Paper also mentions the possible role of biofuels in reducing carbon emissions from transport, stating that, "Alongside renewably-produced hydrogen, fuels made from biomass represent an important potential route for achieving the goal of zero-carbon transport, creating new opportunities for agriculture in the UK as well as globally." The report commits the government to producing an assessment of the overall energy implications of large-scale use of biomass-based fuels by the end of 2003, and to develop roadmaps of the possible transition to these new fuels and vehicles.

3.5 The Energy White Paper recognises the very significant contribution of the UK transport sector to carbon emissions. However, it places strong reliance on the development of new technologies to improve fuel efficiency and power transport with renewable energy. On the other hand, it downplays the importance of sustainable land use policies and behavioural changes that could reduce demand for road transport, stating that, "The movement of people and goods will remain essential for economic success. Rising demand for transport reflects the priority which people attach to mobility. Transport is and will continue to be a highly-valued, high demand commodity."

3.6 The strategy places strong emphasis on improved energy efficiency across all sectors, estimating that "energy efficiency can contribute around half of the additional 15-25 million tonnes of carbon savings we are likely to need by 2020."

3.7 An important policy mechanism for achieving Kyoto targets is the Renewables Obligation, which was put in place in April 2002 to encourage electricity suppliers to source at least 10% of their electricity from renewable generation by 2010. This works on a system of tradable "Renewables Obligation Certificates" (ROCs) which benefit companies meeting or exceeding their yearly targets and penalise companies falling behind. The Renewables Obligation has been a crucial step in creating a favourable market for renewable energy: while "brown" electricity is currently worth 1.6p/kWh (2.6¢/kWh) to companies, "green" electricity is now worth up to 4p/kWh (6.5¢/kWh).

3.8 In order to assess how this 10% electricity target might be met, the UK government commissioned a study to look at the potential for renewable electricity generation on a regional basis. The report indicates that it might be possible to meet the 10% target, but only under a very optimistic assessment of available resources, for example by relaxing planning constraints on the location of wind generators. Scotland, Wales and Northern Ireland may be able to exceed the target, whereas the English regions are likely to fall well short (OXERA Environmental, 2002).

3.9 Another important policy mechanism for achieving CO_2 reductions through demand management is the UK Climate Change Levy, which was introduced in April 2001. The levy is chargeable on the industrial and commercial supply of taxable commodities for lighting, heating and power by consumers in the following sectors of business: industry; commerce; agriculture; public administration; and other services. It does not apply to domestic consumers, charities or transport users. Since its introduction it has been criticised from many quarters for discriminating against small and medium sized enterprises (SMEs) and for failing to encourage energy savings in the household and transport sectors, both of which make up a significant and increasing percentage of UK energy use. As a more fair and effective alternative, proposals have been put forward for a "carbon tax" that would tax all CO_2 emissions directly by charging at the point of wholesale purchase of fossil fuel in all sectors including household and transport, as well as tradable emissions permits (e.g. Royal Society, 2002). So far Government has rejected the idea of a carbon tax on the grounds that it would have a negative impact on the economy.

3.10 A proposal for a new EU Directive on energy demand management is likely to be introduced in summer 2003, covering all sectors except, controversially, aviation and foreign shipping. The likely indicative target would be 1% annual savings in energy efficiency, and each Member State would be able to decide how to distribute this target among sectors (Environment News Service, April 9 2003).

3.11 Over the next 10-20 years, the precise balance of CO_2 savings between renewable energy generation and demand management will be determined by a range of factors, including the relative CO_2 reductions per £ of public money, maintaining competitiveness in national industries, and the public acceptability of fiscal measures designed to reduce demand, but could be in the region of 50:50 (DTI, 2003).

Policy drivers for biomass crop production in the UK

3.12 Plants offer a renewable source of energy, and modern agricultural technologies have enabled intensive large-scale production of crops that could be used for renewable electricity and heat production. These include 'conventional' food crops such as oilseed rape, wheat and sugar beet ('biofuel crops'), as well as perennial crops like short rotation coppice (SRC) willow and *Miscanthus* ('biomass crops')[3]. Although biofuel and biomass crops would both involve dedicated cultivation on agricultural land, the methods of cultivation and processes of energy production are technically and economically quite distinct, so they will largely be discussed separately in this paper.

3.13 There are also a number of other renewable energy technologies that will help to contribute towards renewable electricity targets[4] and a small amount of heat production, including wind, hydro, wave, tidal and solar electricity generation and water heating and various organic waste materials[5]. Biomass-powered electricity and/or heat generators can generally be fuelled by wood from a range of sources including both cultivated and waste woody biomass. Regional and national targets for biomass generation do not seem to distinguish between the relative quantities of each type of fuel. However, quantities of many ‘renewable’ waste materials are relatively limited (e.g. waste vegetable oil) and/or are already being exploited to a significant extent (e.g. poultry litter and landfill gas). Perhaps the greatest opportunity in the future will be the use of pyrolysis or gasification to recover energy from both organic and inorganic domestic and commercial waste (of which the organic element is classed as renewable and would therefore count towards Government targets). From the conservation perspective, using waste cuttings from SSSI management to fuel local biomass electricity or Combined Heat and Power (CHP) plants may be a win-win policy, provided that collection and transport of waste materials is economically and environmentally feasible.

3.14 Biomass (including cultivated crops, forestry residues and poultry litter) is hoped to make up between 11 and 20% of the total contribution towards meeting the government’s 10% renewable electricity target by 2010 (OXERA Environmental, 2002). However, it is not clear from the report whether the assumptions for biomass resource assessment included the suitability of land in terms of climate and/or water availability. An Environment Agency mapping project using GIS to map land deemed ‘suitable’ for SRC willow production (including parameters such as altitude, rainfall, steep slopes and presence of major aquifers) indicates that very limited land resources are available in many parts of England and Wales[6]. Besides these physical constraints, much of UK agricultural land is already committed to long-term land uses such as intensive grassland production for the dairy industry. This could further reduce the proportion of land available for biomass production in specific regions. In fact, research has indicated that it will be a challenge to meet the EU biofuels target for 2010 using UK-produced feedstocks alone (Turley et al, 2002).

3.15 Finding renewable fuels for transport will be more difficult in the short term (up to 2010). Other than electric vehicles with batteries charged by renewably generated electricity (which currently have a limited range), liquid biofuels produced from energy crops or waste vegetable oil may be the only serious option. In the medium to long term (2010-2020 and onwards) the use of hydrogen gas in various forms is likely to become more important, with the ultimate goal of replacing fossil fuels entirely. Hydrogen can be produced by electrolysis of water, but this process requires the input of electricity, which would need to be generated from a renewable source. In the longer term, gasification of woody biomass could be a more efficient source of hydrogen. One study estimates that in 2050 between 50 and 100 per cent of UK road transport could be fuelled using hydrogen produced from biomass crops, but that this would require willow and *Miscanthus* to be grown on around 25% of the total UK agricultural land area (Eyre et al, 2002). However, owing to the constraints on land use described in the paragraph above, it is extremely unlikely that this area of planting would be agronomically and environmentally feasible.

3.16 Increasing the use of renewable sources of energy will not necessarily result in significant net reductions in CO_2 emissions. The efficiency of energy production from biomass (net conversion rate) in terms of area of crops needed is relatively poor in comparison to other renewable energy technologies, and fossil fuel energy input into these systems is often high, although in the future, energy efficiency of electricity and heat production from woody biomass crops is expected to improve with the use of gasification and pyrolysis technologies[7]. Therefore, large areas of land would be needed to grow crops that may ultimately give rather small benefits in terms of CO_2 reductions[8]. The area of biomass crops grown, and the way in which they are managed, could also have significant impacts on farmland biodiversity and water resources, targets which are also important drivers for Government policy (DETR, 1999).

3.17 Costs of setting up and sustaining viable biofuels and biomass industries are also an important consideration. All energy sources are to some extent subsidised or otherwise shielded from the true costs of production (for example, the environmental costs of fossil fuel combustion are borne by taxpayers rather than the consumers of non-renewable energy). There is therefore a good case for Government intervention to support industries with a lower environmental impact. However, of key importance in developing policies to deliver Kyoto targets will be the net cost to the Treasury per kg of CO_2 saved. In the foreseeable future significant financial inputs may be required to create and sustain viable biofuels production industries[9]. In comparison to some (not all) other renewables and demand management technologies, liquid biofuels in particular are likely to represent a poor return on investment[10].

3.18 However, energy efficiency is not the only consideration in renewable energy generation, and biomass and biofuel crops may be attractive to policymakers due to their multifunctional benefits. For example, biomass and biofuel crops could potentially provide a stable source of income to farmers and create new jobs in rural areas. Reflecting this, the UK Government's Strategy for Sustainable Farming and Food, published in December 2002, advocates non-food uses of crops as a part of on-farm diversification[11].

3.19 Levels of financial support, in combination with the way in which support is targeted, together with constraints on land use, will largely determine the area of biomass energy crops planted in the UK and the amount of renewable energy generated from these sources[12]. Policy decisions on support for the biomass energy sector will require careful analysis of the likely costs and benefits to the environment, society and the economy within a sustainable development framework.

3.20 While central Government policy will be a crucial economic driver in terms of establishing fiscal measures to encourage various types of renewable energy and demand management measures, implementation of projects on the ground is under the control of regional, sub-regional, district and unitary authorities. Regional authorities are responsible for researching options and setting targets[13], while district and unitary councils have control over planning permission and therefore wield considerable influence over what happens on the ground. In relation to this, the proposed amendment of Planning Policy Guidance 22, beginning in summer 2003, may help to create a more positive climate for renewable energy installations.

Technology drivers for biomass crop production in the UK

3.21 Advances in science and technology are key drivers in improving the energetic and land-use efficiency of biomass energy production. The creation of a viable biomass energy sector in the UK that contributes in a significant way towards reductions in CO_2 emissions and targets for biodiversity and water resources, will depend in part on the development of new and improved technologies in crop breeding, farm management, harvesting, transportation and processing. Some of these are already being targeted by Government R&D programmes[14]. Processing technologies are currently in the spotlight, since the government-funded flagship project "ARBRE" collapsed due to the use of new gasification technology that failed to work in practice. In the longer term, gasification is likely to become the principal means of converting woody biomass into electricity, but it has now suffered a major setback that, in terms of investor confidence, may take years to turn around.

3.22 Science and technology are also key drivers in the development of other renewable energy sectors, as well as energy efficiency measures. Major advances in other renewable energy technologies could reduce the need for heavy reliance on biomass crops as a source of energy. However, the need to generate hydrogen as a transport fuel in the future is likely to increase demand for biomass within the spectrum of renewable energy sources (Eyre et al, 2002).

3.23 Technology is also a major driving factor in increasing rates of energy consumption – for example, due to the major issue of "standby", the predicted increase in digital TV ownership will have a significant effect on energy consumption. A current analysis of new products shows that low cost digital "Freeview" converters alone could add 3.5 TWh (2.6%) to domestic electricity consumption (Future Energy Solutions, 2003).

Market drivers for biomass crop production in the UK

3.24 Left to the market to decide, it is unlikely that biomass and biofuel crops would form a significant element of energy generation during the next 10-20 years. Government intervention will be important in determining the level of take-up of these technologies, but market factors will determine the extent of intervention required. These include the relative costs of other forms of fossil fuel and renewable energy, as well as prices for imported sources of bioenergy (e.g. imported sugar from Brazilian cane could out-compete home grown bioethanol production).

3.25 Competition between different land uses in the UK will also be important. Demand for certain foods or plant-based industrial raw materials might mean that farmers find it less profitable to grow biomass or biofuel crops. The nature of CAP reform over the next few years is a major uncertainty in this regard.

3.26 Biomass energy and biofuels must also be marketable to consumers. For example, community or domestic-scale biomass boilers may be perceived by consumers as less convenient than a gas boiler due to the need to ensure regular deliveries of a standardised product. Biodiesel used on its own, or as a blend of >5% in conventional diesel, may invalidate the warranty on many new cars. On the other hand, some consumers may be willing to pay a premium for "green" products.

Summary of drivers for biomass and biofuel crop production

3.27 Based on currently available European and UK targets for biomass energy and biofuels, and available sources of waste materials, we might expect to see the following areas of biomass and biofuel crops being commercially cultivated by 2010:

SRC willow and *Miscanthus*	450,000 ha
Oilseed rape	700,000 ha
Wheat and sugar beet	350,000 ha
Total	**1,500,000 ha**

3.28 However, the precise size of these areas, and the way they are distributed across the UK, will be influenced by the following factors:

- Available land area
- Availability and cost-effectiveness of alternative sources of biomass or biofuels (e.g. forestry residues and waste vegetable oil)
- Financial attractiveness to farmers relative to other crops: this will depend both on levels of financial support for growing biomass/biofuels, whether directly to growers through an area-based subsidy or indirectly through reduced taxation on final products, and also on the medium- to long-term

stability of financial returns to farmers – biomass energy crops in particular may operate on long-term contracts

- Likely contribution of biomass/biofuel crop production and processing to other Government objectives e.g. rural development and biodiversity conservation
- Planning permission being given to generating/processing plants within areas suitable for planting
- Technological advances in biomass/biofuels production and other renewables
- Public acceptance/marketability of biomass and biofuels products and the infrastructure needed to generate power from them.

4. The possible contribution of biomass energy crops to sustainable development

4.1 Whatever the extent to which biomass and biofuel crops are taken up in the UK, steps will need to be taken to ensure that they are used in a way that contributes to targets for sustainable development[15]. Of particular interest to English Nature is the potential impact on biodiversity targets.

4.2 The UK has national and international obligations to safeguard its native biodiversity, through the EU Habitats Directive, the EU Birds Directive, and the Convention for Biological Diversity. In the UK much of our biodiversity is closely associated with agricultural systems, and is already being significantly affected by intensification, with many species of farmland birds, butterflies and plants having declined very substantially over the past 50 years. Reversing these declines, while maintaining reasonable levels of production and ensuring a viable income for farmers, is a major challenge, and is likely to require a combination of approaches[16].

4.3 The cultivation, harvesting, transport and processing of biomass energy crops will have direct impacts (both positive and negative) on the biotic and abiotic environment. Clearly, if the use of biomass energy crops contributes to a net reduction in UK carbon emissions, there could be benefits to the environment in the longer term, although biomass energy production from crops in the UK is only likely to make a relatively small contribution to renewables capacity over this timescale. Additionally, there may be indirect impacts resulting from policy decisions relating to support of the bioenergy and/or biofuels industries. For example, policy decisions to provide financial support for bioenergy crops could result in reduced funding for measures that provide greater benefits in terms of carbon emissions reductions and/or wildlife conservation. Biomass energy crops will only make a significant contribution to sustainable development if all of these impacts are taken into account in setting out a coherent strategy for their use in the UK.

4.4 Key factors that will affect the sectors' impact on biodiversity, and sustainable development more broadly, include what area of each type of crop is grown, how the crops are managed, what kinds of land use they are replacing, and the size and location of processing/generation plants. The major drivers for these outcomes are discussed below.

Possible impacts of biofuel and biomass crops on biodiversity and sustainable development

Existing commodity crops

4.5 We already have a good understanding of the environmental impacts of growing the major food crops that could be used to produce liquid biofuels. The likely environmental impacts of expanding the areas of some or all of these crops could be predicted by modelling, although some variables are still uncertain, e.g. whether biofuel crops would be grown on set-aside land; the impacts on pest and disease management of increasing the areas/frequency within rotations of some of these crops; and how intensively they might be managed by farmers. The Central Science Laboratory has produced a draft report on the potential environmental impacts of increased areas of these crops (Turley *et al* 2002), which provides useful information on this subject.

4.6 In order to fulfil the ambitious targets set for biofuels production in the draft EU Biofuels Directive, a major expansion in the area of oilseed rape grown in the UK would be required. At a recent conference on biofuels ("Be Ready for Biofuels", organised by Hutchinsons and United Oilseeds in November 2002), an agronomist suggested that up to 1.6 m ha of oilseed rape could be grown – an increase of almost 400% on current levels. Potentially, up to 400,000 ha of this could be on land that is currently set-aside. Without measures to ensure the retention of some land as set-aside managed for conservation purposes, and to ensure the environmentally-sensitive management of these new oilseed rape crops, there could be significant negative impacts on the environment. In particular, we would be concerned that pest and disease problems in oilseed rape could be intensified if this crop was grown at a higher density in the landscape, and closer together in rotations. On the other hand, under current CAP Mid Term Review proposals for decoupling of direct support to farmers, there could be an increase in the area of winter wheat grown, at the expense of oilseed rape, so measures to improve the profitability of the latter could help to prevent this change.

4.7 In the near future, oils for food use and biodiesel production would have similar compositional profiles, and farmers may be able to respond rapidly to price level changes by switching markets at short notice. In the longer term, we expect novel varieties of oilseed rape with oil profiles better suited to biodiesel production and use, so eventually markets for foods and industrial oils could become segregated. This could potentially make it easier for financial support to be directed specifically at growers of crops for the biodiesel market.

4.8 There is ecological evidence to suggest that oilseed rape is a relatively beneficial crop for biodiversity, in comparison to other autumn-sown arable crops. Up to a point, an increase in the area of oilseed rape grown for biodiesel production could have a beneficial, or at least neutral, impact on biodiversity, if it replaced winter wheat or other winter crops. Spring-sown oilseed rape would be better for biodiversity than autumn-sown rape, since it allows stubbles from the previous crop to remain in the field over winter. However, if winter oilseed rape were to predominantly replace spring crops such as peas or barley, or naturally-regenerated set-aside, the overall impact on biodiversity would probably be negative. Oilseed rape is a nitrogen-hungry crop and could result in increased fertiliser applications if it replaced land uses with low nutrient requirements. This could have negative impacts on water quality.

4.9 Mortimer *et al* (2003) have assessed the energy inputs required to produce biodiesel from oilseed rape. The energy used in the production of nitrate fertiliser accounts for around 23% of total energy inputs and around 50% of total greenhouse gas emissions for the process. They conclude that the energy efficiency of this process can be doubled by using "modified practice" in the cultivation of oilseed rape. This would include a reduction in nitrogen applications from the UK average of 196 kg N/ha to 81 kg N/ha; a reduction in other fertilisers to 57% of current values; fungicides, herbicides and pesticides to 94% of current values; giving a reduction in yield to 2.740 tonnes of dried oilseed rape per hectare. This "modified practice" could deliver significant benefits to biodiversity, but in order to ensure that both carbon emissions and biodiversity benefits were optimised, it would require enforcement through incentives or cross compliance.

4.10 Another recommended practice is to remove the oilseed rape straw for burning, to replace fossil fuels in the processes of drying, solvent extraction, refining and esterification. Rape straw is normally left on the field and ploughed in post harvest, contributing to soil organic matter. The impacts of removing rape straw on soil health and fertiliser inputs later in the rotation may need to be investigated further.

4.11 Several food crops that are high in carbohydrate content are candidates for bioethanol production. Of these, the most energy-efficient and financially viable seems to be wheat. This is currently the UK's most important arable crop, grown on around 2 m ha. Wheat currently fetches a low price on world markets, so UK farmers would benefit from the establishment of a viable bioethanol market in the UK. However, this would require significant levels of financial support, at least while oil prices remain relatively low.

4.12 Intensive winter wheat is generally a poor crop for biodiversity, so any further expansion in the area of this crop could reduce the chances of the UK reaching targets on Biodiversity Action Plan species and the Farmland Birds PSA target. On the other hand, if support for wheat production for bioethanol could be tied to requirements for "modified practices" such as those proposed for biodiesel production, there would be an opportunity to deliver some benefits to biodiversity and water resources.

4.13 Wheat straw can also be burned for heat and/or electricity production, or converted into bioethanol, which would dramatically improve the energy balance of this crop as a biofuel (almost 0.5 units of primary energy are required to produce one unit of bioethanol energy from wheat).

4.14 Potatoes and sugar beet are also suitable candidates for bioethanol production, although both are grown on a far smaller scale than wheat and only have a limited opportunity for expansion in the UK. However, it has been suggested that production for bioethanol could rescue the sugar beet industry from an almost inevitable decline, due to increasing competition from imported sugar. This could provide some wildlife benefits, since sugar beet is a spring crop and if managed sympathetically can provide valuable habitat for overwintering birds.

<u>Novel (woody biomass) crops</u>

4.15 The two main candidates for feedstocks for electricity and/or heat production in the UK are short rotation coppice (willow) and *Miscanthus*. Currently, electricity is generated from these crops by burning them directly, but with technological advances it should also be possible within 10 years to use them for bioethanol production. In the medium term (10-25 years) this may lead to competition among bioethanol and electricity producers for a limited area of biomass crops.

4.16 Short Rotation Coppice (SRC) willow is planted and harvested on a two to five year rotation (usually three). During preparation and the first year after planting, good weed control is advocated to aid establishment. Herbicide use is generally less important after this time. Likewise, fertiliser application is only needed during the first one to two years. However, the impacts on water tables are likely to be significant (when mature they can lower water tables by up to one metre), and this could have adverse impacts on biodiversity, especially if plantations were sited close to wetland habitats.

4.17 There have been some ecological studies conducted to assess the biodiversity supported by SRC willow plantations, mostly in Sweden where biomass crops are widespread. Britt et al (2002) provide a useful review of the impacts on biodiversity of SRC plantations. Ground flora is often sparse where herbicides are used regularly. Where extensive weed populations do occur they are generally dominated by a few species of low conservation value, for example common nettle and rosebay willowherb.

4.18 SRC willow can support large earthworm populations, since the ground is not disturbed by ploughing after establishment. Provided pesticide use is low, large invertebrate populations can be present, including pest species such as willow beetle, and a range of predatory and parasitic species. Sites with a high density of ground cover may support higher populations of herbivorous invertebrates than those that are "well managed".

4.19 SRC willow planted on farmland may provide new areas of suitable breeding habitat for some woodland, scrub and ruderal vegetation bird species, possibly resulting in local population increases. However, species characteristic of open farmland habitats, such as lapwing, skylark, and corn bunting, are unlikely to use SRC crops as a breeding habitat except perhaps in the year of crop establishment and the year following each cut. Where SRC is placed on open farmland, the suitability of these areas as a breeding habitat for these open field species is likely to decrease, at least for most years within the crop rotation (Guy Anderson, unpublished report).

4.20 There is little published information on mammal populations in SRC plantations, but various surveys in the UK have recorded a wide range of species using them, including rabbits, roe deer, brown hare, foxes, various rodents, and two species of bat. Both abundance and diversity of small mammals, such as wood mice, seem to be greater in weedy SRC plots (cited in Britt et al, 2002).

4.21 In summary, SRC willow has the potential to support a wide range of species, some of which are priority species for nature conservation in the UK, although its overall value for nature conservation will depend on what kind of land use it is replacing. If it replaced arable land or improved grassland, it could provide net benefits for biodiversity, whereas if it replaced unimproved grassland or some kinds of set-aside, it could lead to further declines of species that rely on these habitats. SRC that is grown using intensive management practices, such as effective weed control and regular pesticide use, is unlikely to contribute significantly to biodiversity gain in the UK. Therefore, efforts should be made to ensure that farmers follow guidelines, such as those set out in *Short Rotation Coppice for Energy Production: Good Practice Guidelines* (British BioGen/DTI, 1999). This could perhaps be enforced by incorporation of these into standards of Good Farming Practice (possibly changing to Good Agricultural Condition under the latest CAP reform proposals).

4.22 *Miscanthus* is a tall woody perennial rhizomatous grass, which is not native to the UK. It has recently undergone assessments to test whether it would be suitable for growing and production of bioenergy in the UK. It grows rapidly and would be harvested on an annual basis (harvested in February). The annual fertiliser demands of the crop are said to be low due to good nutrient use efficiency and the plant's capability to re-cycle large amounts of nutrients into the rhizomes during the latter part of the growing season. Weed control in the establishment phase of the crop is essential. Once the crop is mature (i.e. from the summer of the second year), weed interference is effectively suppressed.

4.23 We are not aware of any published research on biodiversity in *Miscanthus* plantations, probably since this is a novel crop that is still in the early stages of commercial development. The structure of the crop (a tall, high-density grass) suggests that it would provide poor habitat for arable plants, birds and large mammals, although it could potentially be used by ground-dwelling invertebrates and small mammals. The Defra Best Practice Guidelines on Planting and Growing *Miscanthus* states that it may provide a better wildlife habitat than winter cereals, and that the wildlife value could be increased by the inclusion of rides and headlands.

4.24 Currently, all new SRC plantations over a *de minimis* size threshold are required to undergo an Environmental Impact Assessment (EIA) through the Forestry Commission since they are treated as afforestation. As part of this process, English Nature is consulted, and this provides a mechanism for site-specific issues to be dealt with. *Miscanthus* would be treated differently as it is not a forestry species, so the only circumstance under which an EIA would be required would be if it were replacing uncultivated grassland. There is currently no mechanism under which the overall impacts of planting a large number of plantations of SRC or *Miscanthus* within a particular area can be formally assessed. In particular, the local density of plantations could affect water resources and habitat heterogeneity, with consequent impacts on biodiversity.

4.25 Both SRC and *Miscanthus* can be grown under a range of agronomic conditions, although there are likely to be restrictions on planting on some kinds of land, which could lead to plantations becoming highly concentrated in other areas. The following land types are generally considered to be unsuitable for planting of biomass crops: floodplains, boggy areas or sensitive wetland sites; land with rainfall of under 700 mm; National Nature Reserves; SSSIs; 50m buffer around main rivers; forests; National Parks; Environmentally Sensitive Areas; Areas of Outstanding Natural Beauty; Countryside Stewardship Schemes; areas with a slope of greater than 10%; and Nitrate Sensitive Areas. In addition, certain habitat types may prove especially sensitive, including ancient woodland, hedgerows, wetlands, heathlands, unimproved grassland, peatlands and lowland wet grassland (British BioGen/DTI 1999). The Environment Agency has carried out a demonstration mapping project of suitable areas for planting SRC willow in the UK, and this approach may be useful in assessing the feasibility of biomass power targets (Veitch & McMellin, 2001).

4.26 It has been suggested that bioenergy crop plantations could be used for bioremediation of contaminated soils or to break down organic wastes, such as sewage sludge, that cannot be applied to food crops. While these ideas sound attractive in principle, more research will be needed on the impacts on biodiversity of applying waste materials to soils in these plantations. Genetic modification of native species such as willow to tolerate, avoid or break down soil contaminants would need to be subject to a very stringent risk assessment and, if necessary, incorporate reliable genetic isolation technologies to prevent gene flow to wild species.

Summary of factors determining impact on environment and sustainable development

4.27 Large-scale land use changes associated with the introduction of biomass energy crops will inevitably lead to changes in the biodiversity of farmland. Impacts will depend in part on what types of land use the new crops are replacing, and how intensively they are managed. We do not yet have enough information to predict with any degree of accuracy the nature and magnitude of these impacts, especially how progress on Biodiversity Action Plan, SSSI and Farmland birds targets might be affected. There is an urgent need for more research on the impacts of bioenergy crops, particularly novel crops such as Short Rotation Coppice and *Miscanthus*, before their widespread cultivation is promoted.

4.28 The following factors are likely to be most important in influencing the impacts of biomass and biofuel crops on sustainable development over the next 10-20 years, with particular reference to biodiversity:

- Relative financial incentives and market prices for biomass/biofuel crops and other agricultural land uses
- Incorporation of these areas into agri-environment schemes to reward biodiversity-friendly measures in biomass/biofuel crops
- Decisions on the future of set-aside under CAP reforms
- The success of the land use planning system in ensuring that new generation and processing plants have an acceptably low impact on the environment, and in protecting SSSIs and unimproved grasslands that are valuable wildlife habitats
- Technological advances enabling greater energy efficiency in biomass or biofuel production systems and improved reduction in CO_2 emissions per unit area of crop grown
- Development of new crop varieties that require lower inputs of agrochemicals and/or have higher nutrient or water use efficiency
- Development of crop management and harvesting technologies to reduce the need for energy-intensive and/or environmentally polluting inputs and to improve the value of biomass and biofuel crops for biodiversity
- Our ability to understand and predict environmental impacts of growing these crops on a large scale
- Size and location of generation/processing plants, including whether they make a significant contribution to employment of local people, the distance required to transport raw materials and the resulting impacts on road traffic levels
- With particular reference to woody biomass crops, the density of planting around a power station and the resulting landscape heterogeneity and impact on visual amenity
- Ability of biomass and biofuel crops to contribute towards the development of small-scale, locally owned renewable energy systems that do not result in higher costs to consumers on low incomes

5. Potential for biofuel/biomass crops to bring positive outcomes for biodiversity

5.1 Reversing the declines of many species of plants and animals in our countryside will depend on the adoption of more environmentally sustainable farming practices. Based on the evidence discussed in this paper, we conclude that bioenergy crops could contribute towards the conservation of biodiversity in the UK if:

- they replace crops or land uses that are known to support less biodiversity
- they do not hamper the conversion of agricultural land to more wildlife-friendly habitat such as species-rich grassland or even ‘wilderness’
- they can be demonstrated not to adversely affect the quality or quantity of water resources, and the biodiversity of aquatic environments
- they are managed in a way that has been demonstrated to benefit wildlife
- they increase landscape heterogeneity in comparison with existing patterns
- effective safeguards on the scale and location of planting of biomass crops are put in place
- they are not grown in locations where they could adversely affect protected sites
- their use is supplemented by organic materials derived from waste
- processing and/or generation plants do not adversely affect air quality
- long-term monitoring is implemented to identify environmental impacts

6. English Nature’s role

6.1 Many of the factors influencing the extent of adoption of biomass energy systems, and the way in which they are used, will be determined by Government, either directly through policy development, or indirectly through funding for science and technology research and development that could alter the way these crops are grown. English Nature has particular opportunities to influence these areas, and we suggest the following areas of engagement as priorities for the organisation:

- Continued strong emphasis on the crucial role of energy efficiency, and the difficult area of demand management, in reducing demand for energy in the UK (includes development of “sustainable” communities that reduce demand for transport/energy and local energy generation schemes)
- Support for systems involving energy production from organic waste, including where appropriate as outlets for waste cuttings from SSSI management
- Protection of set-aside for conservation management as long as set-aside remains as a specific component of agricultural policy.

- More research/monitoring on environmental impacts of growing biomass/biofuel crops

- Development and uptake of management practices for biomass and biofuel crops that conserve and enhance biodiversity and water resources and maximise efficiency of energy production (perhaps through low-input systems), potentially including development of agri-environment prescriptions for woody biomass crops

- Pressing for more engagement between developers, planners, statutory bodies and other stakeholders in the development of plans for large-scale biomass energy generation plants, in advance of planning applications being submitted

- Developing partnerships with other stakeholders, including industry, NGOs, Environment Agency, Countryside Agency and other statutory conservation agencies

- Providing sound, objective and evidence-based advice to Government on issues relating to the impacts of biomass and biofuel crops on biodiversity and sustainable development

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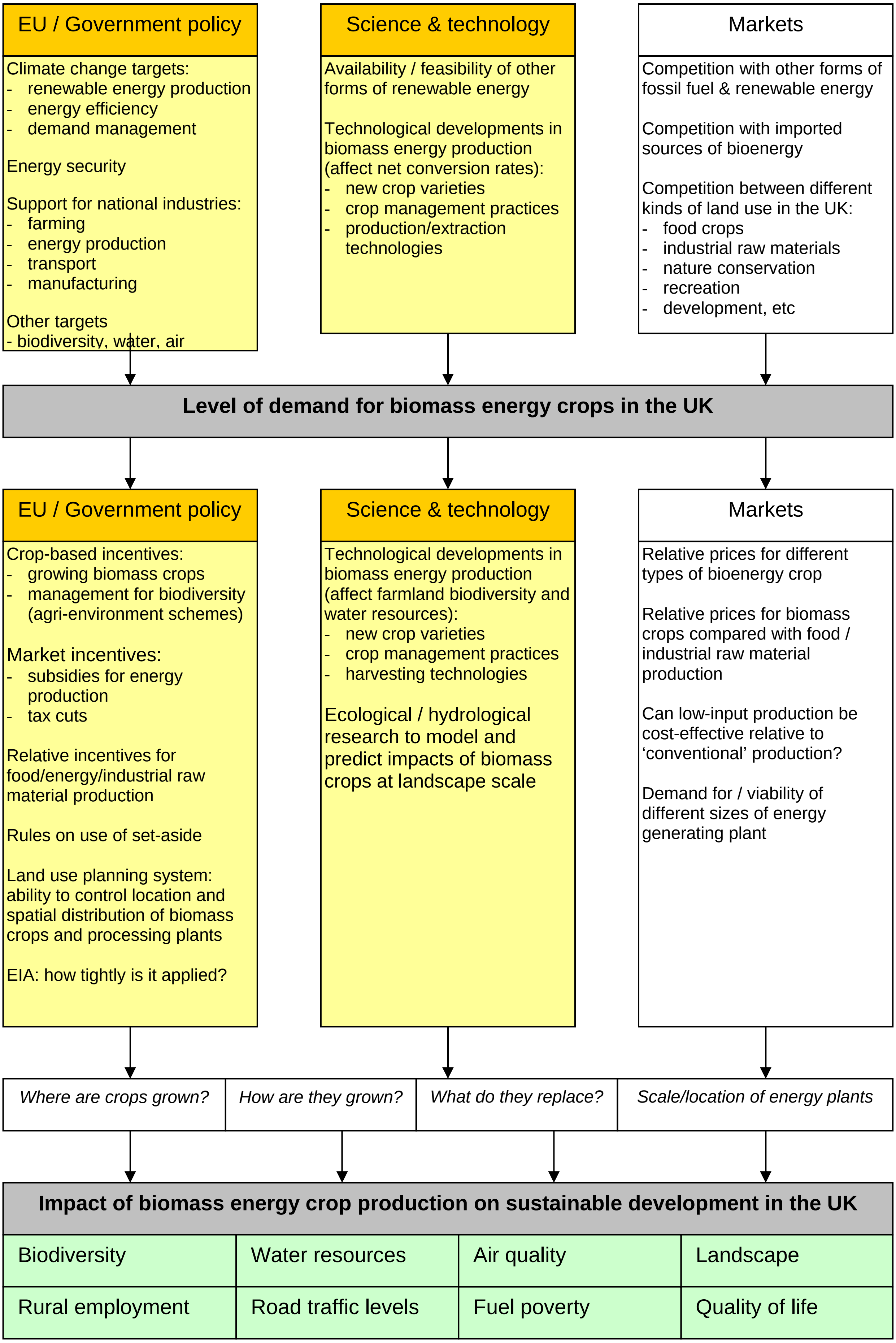
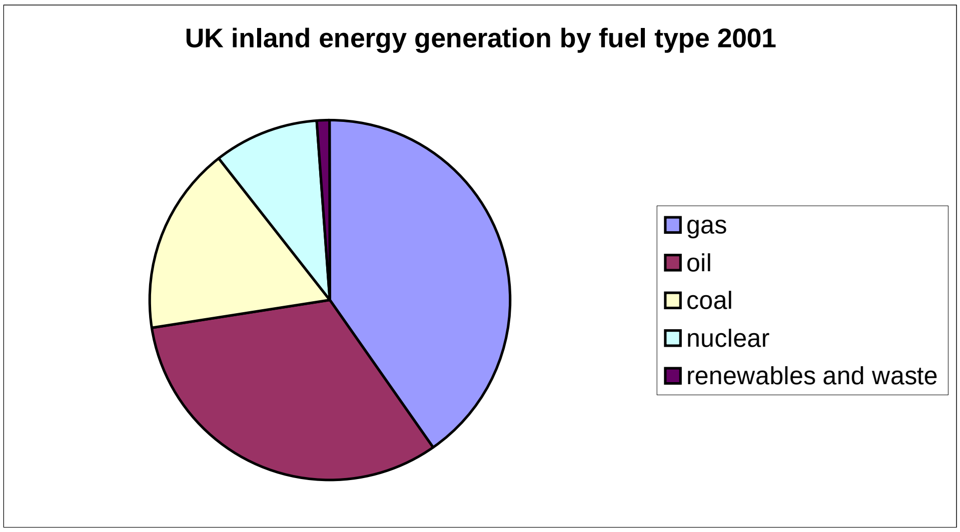
Drivers of possible impacts of biomass energy crops in the UK **ANNEX A**

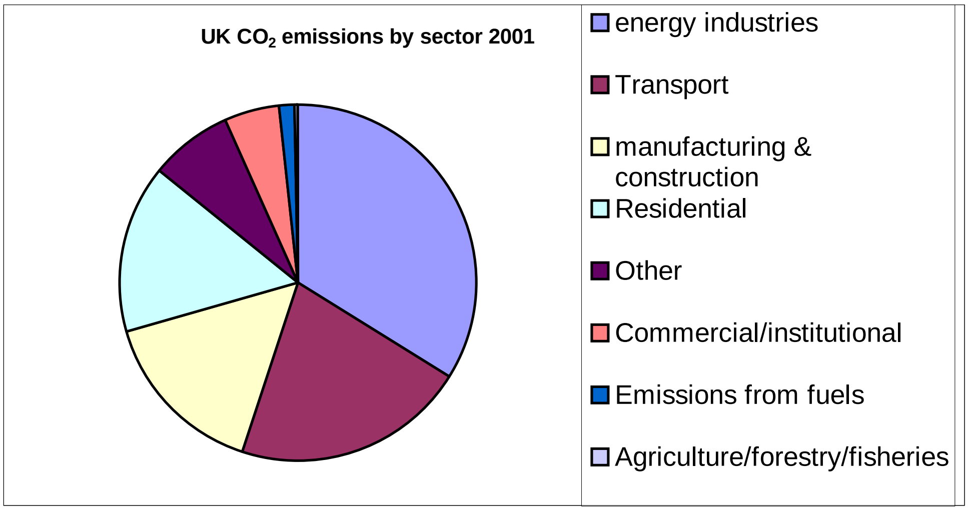


BACKGROUND NOTES

[1] The chart below shows the UK inland energy generation by fuel type for 2001. Total was 237.7 million tonnes of oil equivalent (mtoe) (DTI, 2002).



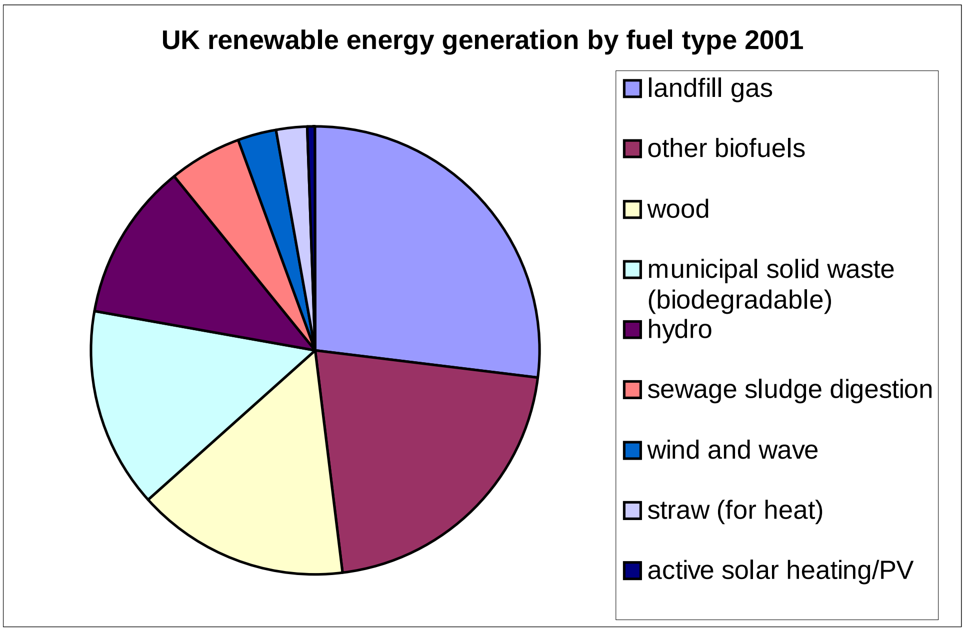
[2] The chart below shows UK CO_2 emissions by sector in 2001. Total was 544 million tonnes of CO_2 (European Environment Agency, 2003)



[3] In this document, we use 'biomass crops' to describe crops or trees that are grown specifically to be burned for energy generation, and 'biofuel crops' as those that can be converted through processing into fuels for transport use. Biodiesel has very similar properties to conventional diesel and can be used as a substitute in diesel engines (usually as a 5:95 blend); bioethanol is produced using fermentation of starch-based materials and can be blended with conventional petrol (gasoline). The principal crops that could be grown as bioenergy crops in the UK are:

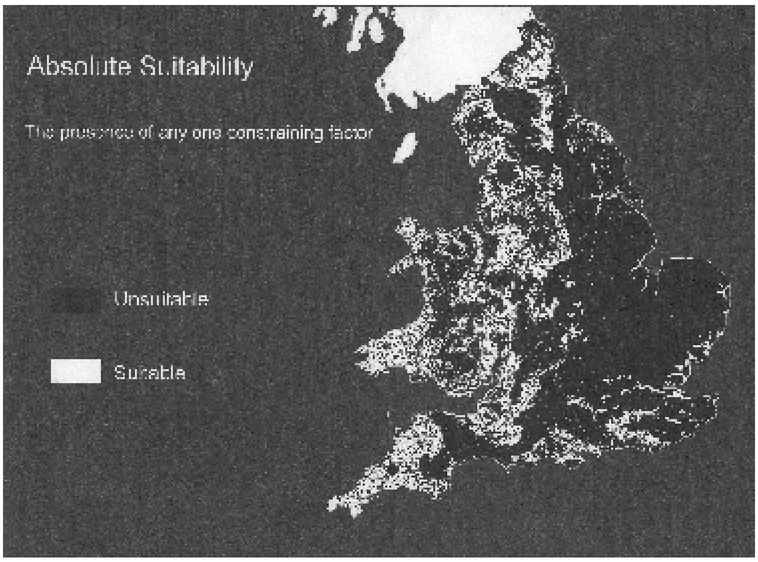
Crop	Electricity	Heat	CHP	Biodiesel	Bioethanol
Willow (short rotation coppice)					
Miscanthus					
Oilseed rape	waste straw	waste straw	waste straw		
Wheat	waste straw	waste straw	waste straw		
Sugar beet					
Potato					

[4] The chart below shows the UK renewable energy generation by fuel type for 2001. Total was 3.1million tonnes of oil equivalent (mtoe) (DTI, 2002).



[5] For example, material arising from management of forests, gardens, parks and nature reserves, and some domestic waste can be burned for heat and/or electricity, waste oils from food processing plants and restaurants can be used to produce biodiesel, and cellulose fibre from paper and cardboard can be fermented to produce ethanol.

[6] The Environment Agency constraints mapping project used data on a number of parameters to assess suitability of land for SRC in England and Wales. The white areas on the map below show areas that would be suitable for growing willow, while dark areas indicate the existence of one or more unfavourable factors: presence of major aquifer; high number of abstractions; altitude >300m; unsuitable habitat type; urban area; SSSI or other designation; slope >10%; low rainfall (Veitch & McMellin, 2001).



[7] Areas needed for net energy production vary according to the thermodynamic efficiency of the specific system. Solar photovoltaic cells can generate 0.7 GWh/ha/year of electricity; wind farms can generate 0.2 GWh/ha/year, but biomass crops can only achieve 0.02 GWh/ha/year (International Energy Agency/OECD 1998).

The table below illustrates average figures for energy requirement to produce 1MJ of energy from selected biofuel and biomass technologies (from Elsayed et al, 2003 and Mortimer et al, 2002)

Selected Biofuel Technology	Energy Requirement (MJ/MJ)	Efficiency (%)
Biodiesel from oilseed rape (conventional production)	0.44	56
Biodiesel from oilseed rape (modified production)	0.21	79
Biodiesel from recycled vegetable oil	0.19	81
Combined Heat and Power (large scale with industrial load) by combustion of wood chip from forestry residues	0.14	86
Electricity (large scale) by combustion of miscanthus	0.27	73
Electricity (large scale) by combustion of straw	0.71	29
Electricity by combustion of wood chip from short rotation coppice	0.35	65
Electricity by gasification of wood chip from short rotation coppice	0.15	85
Electricity by pyrolysis of wood chip from short rotation coppice	0.31	69
Ethanol from lignocellulosics (wheat straw)	0.02	98
Ethanol from sugar beet	0.50	50
Ethanol from wheat	0.46	54
Heat (small scale) by combustion of wood chip from woodland management	0.09	91

[8] The table below illustrates the approximate areas of some biomass energy crops needed to supply UK needs in the short term.

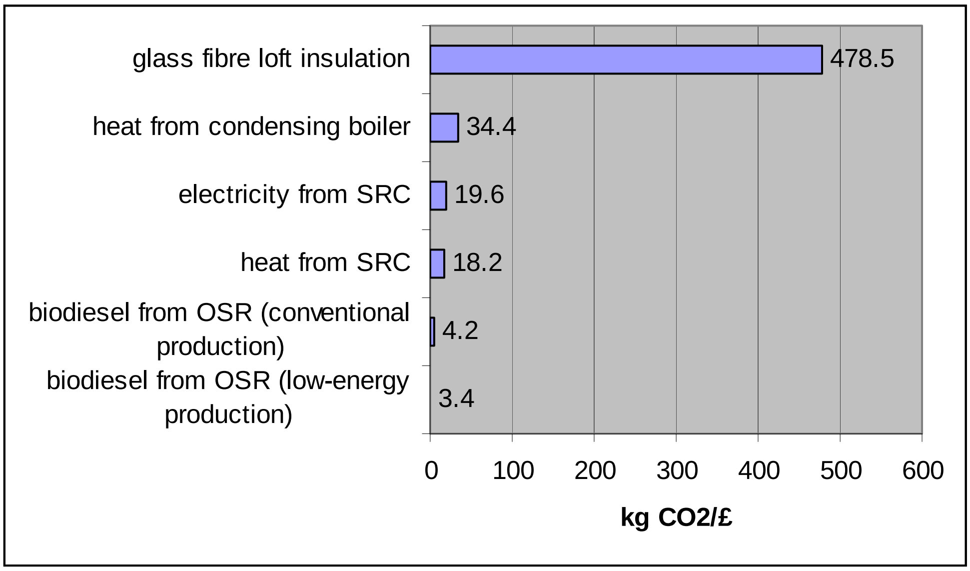
Fuel type	**Crop**	**Conversion rate**	**Government target**	**Area needed (million ha)**	**% UK agricultural land area [a]**	**Area under cultivation in 2002 (million ha)**
Biomass (for electricity)	Short Rotation Coppice	~ 2.2 kW ha^{-1}	4.6 GW (2010) [b]	2.07	11	< 0.01
			1 GW (2010) [c]	0.45	2.4	
	Miscanthus	~ 2.13 kW ha^{-1}	4.6 GW (2010)	2.16	12	< 0.001
			1 GW (2010)	0.47	2.5	
Biodiesel	Oilseed rape	~ 1.1 t biodiesel ha^{-1}	0.2 mtoe [d] (2005)	0.18	3 [e]	0.43 (of which 0.08 on set-aside)
			0.8 mtoe (2010)	0.7	12 [e]	
Bioethanol	Wheat	~ 2.9 t bioethanol ha^{-1}	0.4 mtoe (2005)	0.13	2 [e]	2.0
			1.2 mtoe (2010)	0.41	7 [e]	
	Sugar beet	~ 4 t bioethanol ha^{-1}	0.4 mtoe (2005)	0.1	1.7	0.17
			1.2 mtoe (2010)	0.3	5	

[a] In June 2002, the total agricultural area of the UK was 18.4 million ha (Defra Statistics)
[b] UK Government target of 10% electricity to be from renewable sources by 2010 (assuming for the purposes of this calculation that all energy would come from biomass crops)
[c] Target suggested by British Biogen (equating to 2% of total energy use)
[d] million tonnes oil equivalent
[e] % UK *arable* area (these crops would only be grown on land suitable for arable crop production) – total arable land area was 5.8 million ha in 2002 (Defra Statistics)

The table has been compiled from a variety of sources including:
Digest of Environmental Statistics, DEFRA, October 2002
British BioGen website: www.britishbiogen.co.uk
Future Energy Solutions www.etsu.com

[9] For example, the British Association of Biofuels and Oils (BABFO) recommends a 40p/l cut in fuel duty for biofuels. In order to reach the proposed EU target of 5.75% biofuels by 2010 this would cost the UK government over £1bn (US$1.6bn) per year, for an estimated CO_2 emissions reduction of 3.7 million tonnes per year, or 0.7% of total UK emissions. During this period, energy demand for road transport is projected to rise by between 5 and 150 PJ (depending on innovations in fuel efficiency), roughly equivalent to 0.1-2.5 million tonnes of carbon per year (Eyre et al, 2002).

[10] Mortimer et al (2002) estimate the net CO2 saving cost effectiveness of various biomass and biofuels technologies in comparison to energy efficiency measures, all of which could be supported by Government funding:



[11] Prices for commodity crops, particularly wheat, are very low and the production of bioenergy crops has been suggested as a way for farmers to maintain their incomes. Producing energy from biomass and biofuel crops requires dedicated infrastructure systems, including guaranteed supplies of raw material, transport systems and processing plants. It has been suggested that the establishment of such production systems in rural areas would create new employment opportunities in rural areas. However, this would depend on production systems being located in areas of employment need.

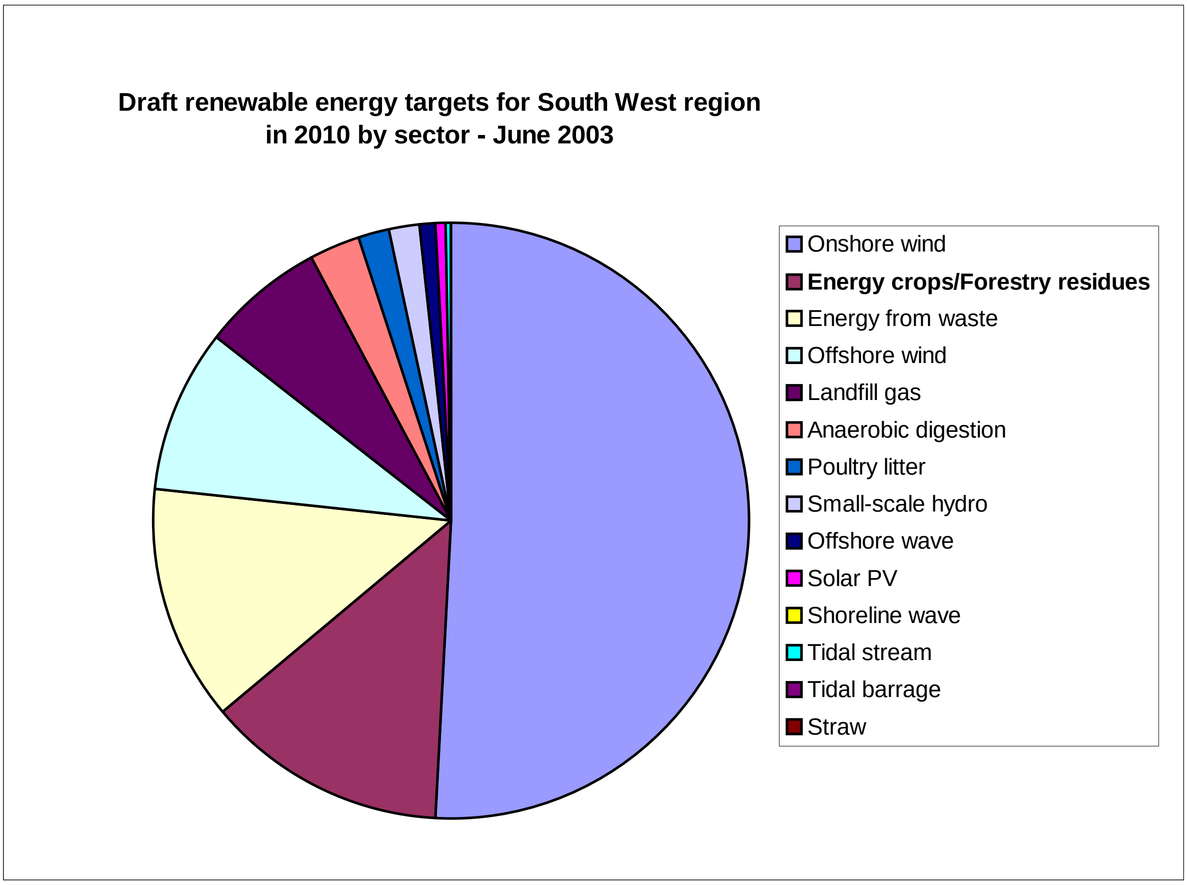
[12] In recognition of the potential contribution that bioenergy crops could make towards emissions targets and rural development objectives, various initiatives have already been set up in the UK and the EU to promote their use:

Defra's Energy Crops Scheme, part of the England Rural Development Programme, provides assistance for farmers through establishment grants for Short Rotation Coppice and *Miscanthus*, with funding for growers to set up producer groups. £29 million (US$47 million) has been allocated over five years.

The £66 million (US$107 million) Bio-energy Capital Grant Scheme is a UK-wide joint initiative funded by the Department of Trade and Industry and the New Opportunities Fund, with input from Defra. It could support the establishment of up to six power stations and up to a hundred smaller power and heat plants. The scheme is for project developers and organisations that are considering investing in heat and/or electricity generating projects fuelled by energy crops (not in England) and other biomass feedstocks.

The EC Biofuels Directive proposes that an increasing percentage of the diesel and gasoline sold in each of the EU Member States should be biofuel, rising from 2% in 2005 to 5.75% in 2010. These targets are not mandatory, but Member States will have to inform the Commission of the measures they have taken to reach these targets. If targets are not met *for reasons that are unjustified and/or do not relate to new scientific evidence*, mandatory targets will be set by the Commission. Individual Governments can introduce a duty differential of maximum 50% of the excise duty levied on the corresponding normal fuel, which could be increased to 100% for fuel used in public transport and for heating oil.

[13] For example, the Government Office for the South West (GOSW) and the South West Regional Assembly are funding the REvision 2010 project to facilitate the identification and then adoption of sub-regional renewable electricity targets. A regional assessment of the potential for renewable electricity in the South West has been undertaken and determined that the region should be able to achieve 11%–15% of electricity generation from renewable sources by 2010. The chart below shows draft targets by energy sector (www.oursouthwest.com/revision2010/).



[14] DEFRA's Science Strategy published in 2003 includes targets for doubling yield in willow and *Miscanthus*.

[15] The UK Government's "headline indicators" for sustainable development (DETR, 1999) include:

- Total output of economy
- Total & social investment as a % of GDP
- Proportion of people in working age who are in work
- Elderly in fuel poverty
- Emissions of greenhouse gases
- Road traffic
- Rivers of good or fair quality

- Populations of wild birds
- Waste arisings and management

[16] Measures likely to increase biodiversity on farmland include:

- An increase in habitat heterogeneity at both farm and landscape scale, through the establishment of more diverse rotations (including mixed farming);
- Increased adoption of organic and low-input farming methods (facilitated by the development of crop varieties that perform well under a low-input regime);
- Use of agri-environment schemes to encourage wildlife-friendly practices, such as conservation headlands and over-winter stubbles in arable cropping rotations;
- Uncropped land to be managed for wildlife (e.g. environmental management of set-aside)