Institute for European Environmental Policy

SECURING BIOMASS FOR ENERGY – DEVELOPING AN ENVIRONMENTALLY RESPONSIBLE INDUSTRY FOR THE UK NOW AND INTO THE FUTURE

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EXECUTIVE SUMMARY

As the UK gears up for a major expansion in bioenergy supply, a strategy for making best use of this valuable but environmentally very sensitive resource is needed. The share of renewable energy in national supplies has the potential to rise to 30 to 45 per cent by the year 2030 and under the Renewable Energy Directive will need to increase from 3.3 per cent in 2010 to 15 per cent in 2020. Reaching these medium and longer term targets requires considerable effort in stepping up renewable energy deployment.

According to the UK National Renewable Energy Action Plan (NREAP), around half of the renewables target will be met by bioenergy, with the largest contributions anticipated in the heating and cooling and the transport sectors. Reaching such targets is only possible if appropriate policies are in place. Those for bioenergy require particular attention because of the environmental sensitivities associated with most bioenergy sources: wrongly directed policies can give rise to serious risks as illustrated by recent experiences with biofuels.

Sources and Supply Chains

Bioenergy can be produced from a range of *different biomass sources* which vary greatly in their characteristics and the implications of their use. One group consists of waste streams such as food waste, municipal waste, sewage sludge and landfill gas. Another group comprises residues and co-products from the agricultural and forestry sectors, including animal slurries as well as straw and residues from forestry and wood processing activities. Finally, there is dedicated biomass from forests and agricultural land and material arising from landscape and habitat management. Policy needs to make clear distinctions between these sources where they are needed rather than lumping them together.

Bioenergy can serve a range of *different end-uses* across various technology pathways. These include combustion of solid biomass from the domestic to industrial scale, anaerobic digestion to produce biogas and (among others) fermentation and crushing to produce bioliquids. Biomass derived energy can meet heat, electricity and transport fuel demands separately or sometimes in combination. This report seeks to address the spectrum of bioenergy sources expected to be deployed in the UK except for biofuels which raise significant issues of additional concern.

Domestic versus imported bioenergy supplies

As demonstrated in **Chapter 2**, the UK Government's current plans translate into a more than three-fold increase in bioenergy supply between 2010 and 2020 implying that bioenergy would contribute around 50 per cent to the UK renewable energy target. Imports are anticipated to account for about 40 per cent of total supply in 2020, or 6.09 Mtoe out of the 10.4 Mtoe target. There are very serious questions about the sustainability of large scale imports and this substantial reliance on imports casts doubts about the viability and durability of the present bioenergy strategy. It will be much harder to monitor and enforce sustainability standards which will be required in future if they have to encompass all forms of bioenergy drawn from a range of third countries of supply.

It is therefore pivotal to redirect efforts to fostering domestic supplies of UK bioenergy in a way that brings about greenhouse gas savings and wider environmental benefits without expanding onto existing agricultural and high nature value land and hence compromising on food, feed and nature protection needs. Because the bulk of UK biofuel use is anticipated to be met by imports and because today's prevalent first-generation biofuels rely heavily on food and feed crops as feedstocks, this report does not cover biofuels. Instead it focuses on environmentally responsible solid and gaseous bioenergy. It is clear that supplies in these categories can be expanded very considerably without any recourse to dedicated energy crops. Waste products, residues, by-products of current activities and unexploited resources make up the great majority of this total. Some will become commercially viable only with significant incentives. The scale of supplies is hence sensitive to policy assumptions. Due to the often diffuse nature of these bioenergy sources, they will mostly feed into smaller-scale commercial, domestic and community renewable energy generation plants.

An environmentally responsible biomass hierarchy

Given the environmental sensitivities surrounding different bioenergy sources (discussed in **Chapter 3**), the report proposes a sustainability hierarchy to guide a strategic approach for exploiting the UK's domestic resource and developing a suite of sectoral policy tools to implement it. We adopt a modified version of a hierarchy previously developed in another study (Gove *et al*, 2010). This hierarchy of biomass feedstocks incorporates the principles recently put forward by the Environment Agency (2009a/b) and seeks to deliver environmental benefits beyond greenhouse gas savings. The bioenergy resources offering the greatest environmental benefits are at the top of the hierarchy which is as follows:

(1) Genuinely residual wastes;
(2) Arisings produced by habitat conservation and landscape management;
(3) Agricultural and forestry co-products and residues;
(4) Biomass harvested from new and existing woodlands;
(5) Dedicated energy crops.

A strategic approach to the development and deployment of bioenergy is essential if the resource is to make the greatest contribution to reducing GHG emissions, diversifying renewable energy supply and the sustainable management of the natural environment. The Government should prepare and implement such a strategy within the broader framework of energy policy.

Measures need to be designed in such a way as to prioritise the more sustainable sources of supply in the hierarchy and balance investment in deployment technologies with the overall resource available, which will change over time. Since this supply is subject to clear limitations and regional variations, some coordination and planning in essential. As with other energy sources investment in conservation is required alongside the mobilisation of new supplies.

Recommendations for renewable energy policy

UK renewable energy policy provides the framework for developing bioenergy responsibly, as elaborated in **Chapter 6**. Our headline policy recommendations for renewable energy policy makers are:

- to promote the environmentally preferable bioenergy feedstocks by changing the banding of the Renewables Obligation to include a 'ROC-environmental bonus' reflecting not only the economic costs but also the full environmental costs and benefits of the energy sources used according to the hierarchy put forward here;
- to integrate the same principle of internalising the key environmental costs and benefits in the support scheme of the Renewable Heat Incentive;
- to monitor the effects of renewable energy policy on dedicated energy cropping so as to detect any unintended increase in the planting of maize or other arable crops in response to bioenergy supply incentives. For example, anaerobic digestion operators should report on the share of agricultural crops, in their feedstock resource base so as to establish an advanced warning system of any surge;
- to reduce the transaction and administration costs associated with scattered bioenergy sources such as small woodlands by setting up regional biomass trade and logistic centres coordinating biomass suppliers and users so as to develop supply chains and markets;

Advancing CHP deployment rather than electricity-only power plants is imperative in order to use the existing bioenergy resource efficiently. Enhanced support for CHP as part of the Renewable Heat Incentive, the siting of power plants based on heat loads and granting power to local authorities to withhold consent from developers whose proposals do not involve connection to a heat network would help to promote CHP and the development of district heating networks.

There is a need for a forward planning capacity to appraise the supply resources and options in a broad environmental framework, take account of regional capacity and provide oversight of developments, such as combustion plants, so that they are compatible with the feedstocks available and that we do not become locked into an unsustainable infrastructure through uncoordinated local developments. An observatory to do so could be established in an existing agency.

Recommendations for sectoral policies

While renewable energy policy sets the overall incentive framework, sectoral policies have an important role to play in providing impetus for a dynamic development of environmentally responsible bioenergy supply chains whilst also putting in place safeguards to mitigate negative environmental impacts.

We have analysed current policies in the waste, agriculture and forestry sectors that are relevant for the different bioenergy supply chains (**Chapter 4**). Based on this we have identified in **Chapter 5** necessary changes in these policy areas to exploit the UK's potential for environmentally responsible bioenergy:

- Energy from waste must not compromise the waste hierarchy. We hence support the Government's appraisal of favouring prevention over re-use, recycling, composting, energy recovery and landfilling reiterated in the June 2011 Review of Waste Policy.
- Improved waste collection and separation infrastructure to make energy from waste solutions economically viable. One area for policy innovation would be to pool local authority resources or public procurement contracts to collect food and other forms of waste from a larger number of households.
- Protect permanent grasslands from detrimental impacts of bioenergy development. The continued use of Environmental Impact Assessments is needed to protect uncultivated or semi-natural areas of more than two hectares in size from agricultural intensification, whereby the appropriateness of the two hectare threshold should be monitored and lowered, if it is found that significant conversions have occurred below this threshold.
- There is considerable potential to make more use of straw as a renewable resource. Guidance should be provided to farmers on the most sustainable use of surplus straw (and other crop residues). In some situations improving soil structure and organic matter content by incorporation in the field will be a higher environmental priority than using straw as a biomass feedstock.
- Encourage the management of the considerable area of undermanaged woodlands and the restoration of planted ancient woodland sites (PAWS) while adhering to the requirement for sustainable management in the UK Forestry Standard. The Forestry Commission's Woodfuel Implementation Plan 2011 – 2014 for England has made a step into the right direction. Support should be targeted specifically at owners of undermanaged woodland located on farms that are currently not reached by Forestry Commission activities. New woodlands can contribute to various environmental objectives, such as habitat restoration and linking up or buffering fragmented woodlands as well as their role as carbon sinks. Appropriate planning is needed to ensure that new woods are established in the most suitable locations.

Questions and considerations on environmentally responsible bioenergy arise not only in the UK but also in other EU Member States which together anticipate meeting half of the EU's 20 per cent renewables target for 2020 by bioenergy. UK policy needs to both develop within an EU framework and inform the wider debate in Europe, showing leadership where this is appropriate. Bioenergy policy is still very much an evolving process: well thought through solutions that are developed now in one country may well find a place in other Member States' strategies.

1 INTRODUCTION

Renewable sources of energy will play a central role in meeting the UK's decarbonisation targets over the coming decades. While currently representing only a small proportion of gross final energy consumption in the UK, 3.3 per cent in 2010[1] renewables are envisaged to reach a 15 per cent share by 2020. This is the UK's target under the EU Renewable Energy Directive[2] (RED). The Climate Change Committee sees 'scope for significant penetration of renewable energy' of up to 30 to 45 per cent by 2030[3]. Bioenergy in various forms will play an important role in renewable energy supply, possibly contributing about half of the overall national renewable energy target according to the UK National Renewable Energy Action Plan (NREAP)[4]. The largest contributions will be in the heating and cooling and transport sectors. Bioenergy is and will continue to be produced from a range of different sources of biomass. These are converted into useful energy by a variety of technologies which are changing over time. The key production chains involved at present are shown in Figure 1[5].

Given the anticipated scale of bioenergy deployment over the next decade and beyond, the main aim of this report is to explore how to exploit the UK's domestic bioenergy potential in an environmentally responsible way and to identify the policy mechanisms required to achieve this. This requires a longer term sustainability focus rather than concentration on options that appear cost effective in the short term. There are grounds for serious concern about a bioenergy strategy based heavily on imports of fuels or feedstocks, not least because these might constitute over 85 per cent of the current target level of biofuel supply in the UK by 2020 according to the UK NREAP. The report focuses on bioenergy produced from UK sourced biomass, concentrating on solid and gaseous biomass and not on biofuels/bioliquids that are produced from agricultural crops which have alternative uses in the food and feed sectors. Due to their often diffuse nature, the bioenergy feedstocks propagated here will mostly feed into smaller-scale commercial, domestic and community renewable energy generation plants. Biofuels[6] are excluded here both because they are mainly imported and because those produced from domestically grown feedstocks occupy land that would otherwise be used for food and feed and are generally characterised by low energy yields, and hence low or in some cases negative emission savings potential, per hectare once indirect land use change (ILUC) is taken into account.

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[1] See eg Committee on Climate Change (2011).

[2] Directive 2009/28/EC of the European Parliament and of the Council of 5 June 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

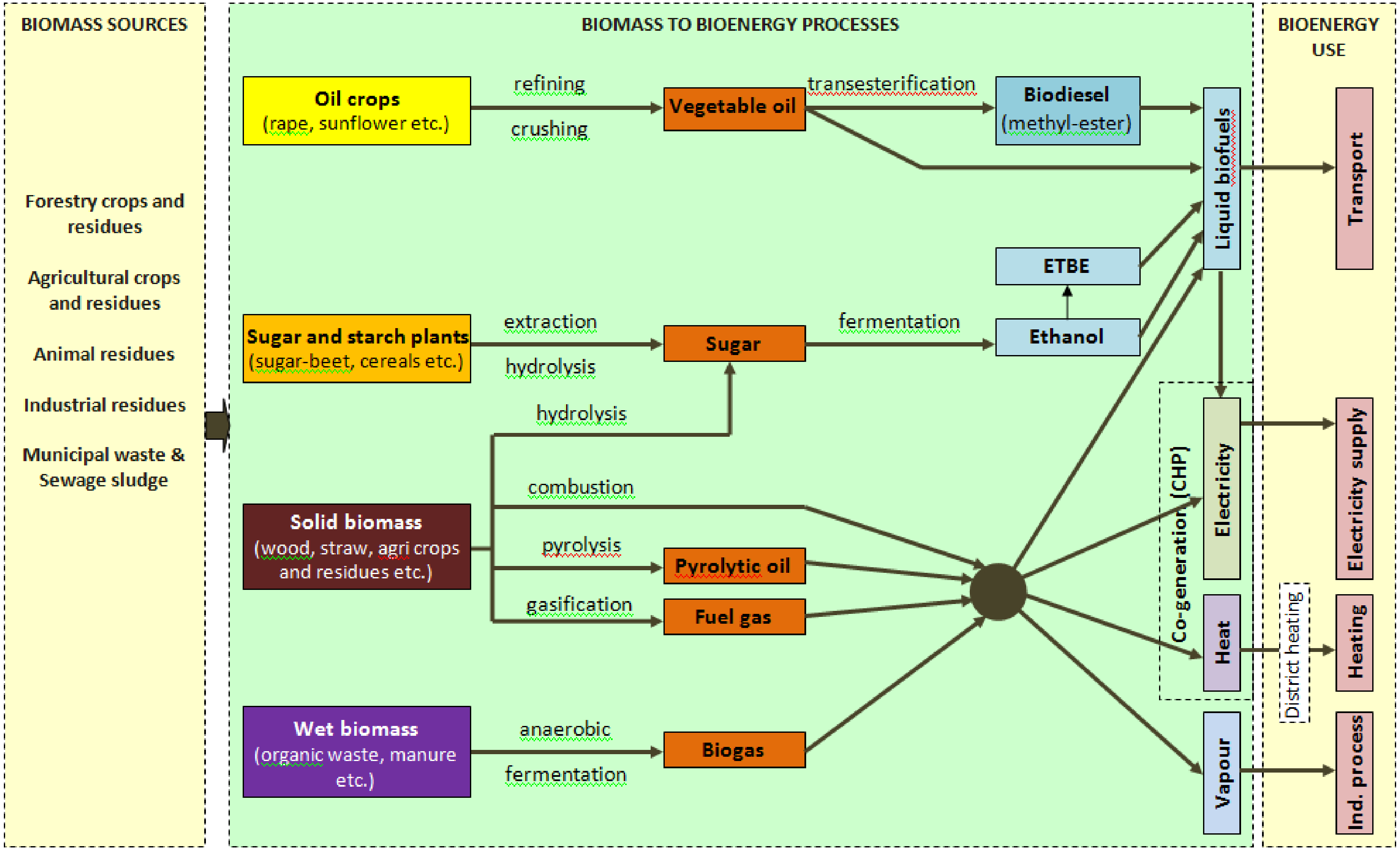
[3] 30 per cent in the central scenario and 45 per cent in a maximum feasible scenario (Committee on Climate Change, 2011).

[4] National Renewable Action Plan for the United Kingdom, available at http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/ored/25-nat-ren-energy-action-plan.pdf.

[5] Based on the Blue Planet Energy diagram from http://www.blueplanet-energy.com/.

[6] The UK plans to rely exclusively on first generation fuels for 2020 according to its NREAP.

Figure 1. Biomass pathways from resource to energy products



Note that while the diagram includes biofuel technologies, we do not tackle biofuel production within the report, as stated in the main text.

The main underlying rationale for supporting renewable energy sources, including bioenergy, is to reduce reliance on non-renewable sources of energy such as fossil, to cut greenhouse gas emissions (GHG), and to diversify energy sources. From an environmental perspective, bioenergy warrants special attention compared to other renewable energy sources both in relation to potential risks and benefits. As bioenergy production can put considerable demands on finite land resources it must be used efficiently to deliver maximum levels of energy services. Linkages between bioenergy provision and a range of environmental priorities, relating to biodiversity, climate change, the health of soils and wider environmental resource management are particularly strong. While the risks of negative impacts are considerable and need to be addressed, there are also potential environmental benefits that other forms of renewable energy generally do not offer. Environmental factors beyond climate mitigation considerations are therefore central to the formation of a robust strategy and set of policy instruments for developing bioenergy. Bioenergy supplies must be sustainable in a wider sense than simply doing no serious harm to the environment, which sometimes appears the aim of sustainability criteria adopted under EU legislation. This report advocates a more positive approach that strives to generate additional environmental benefits besides increasing supplies of a significant renewable energy resource.

The approach is as follows. Section 2 sets the scene by introducing the current of uses of bioenergy in the UK as well as their anticipated scale up to 2020. Section 3 discusses the main environmental challenges associated with bioenergy development and proposes a biomass feedstock hierarchy as a frame for policy. Section 4 examines the different feedstocks in detail and in relation to their availability, relevant environmental constraints and the current policy framework applicable to them. Section 5 analyses a number of legislative/regulatory barriers that need to be addressed. Section 6 proceeds to investigate whether current UK renewable energy policy is designed in such a way as to promote the most environmentally benign feedstocks and discusses bioenergy in the wider energy system. Section 7 concludes with policy recommendations.

2 THE UK'S BIOENERGY RESOURCE

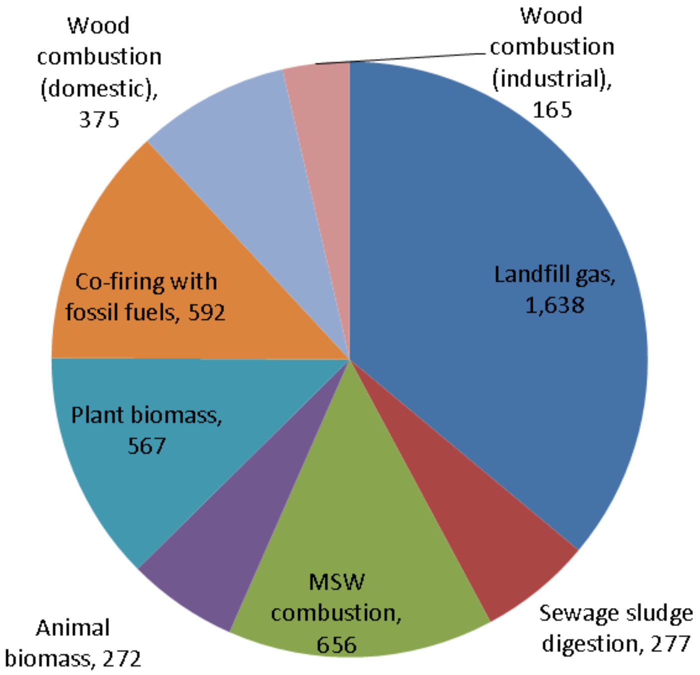
The current structure of UK bioenergy sources and their potential evolution up to 2020 and beyond is set out in this section. The role of bioenergy/biomass imports is also explored briefly with a discussion of their potential scale and sustainability issues.

2.1 Current UK bioenergy use and the domestic resource

Figure 2 shows the overall scale and relative significance of the range of biomass feedstocks used in the UK in 2009 on a fuel input basis for both heat and electricity generation (all converted to ktoe, thousand tonnes of oil equivalent), giving a total of 4.54 Mtoe (million toe) primary energy from biomass. The NREAP anticipates the deployment of 6.09 Mtoe primary energy production from domestic biomass by

2020[7]. However, it is through imports that the main increase in bioenergy is expected. Looking at overall bioenergy consumption, including imports: Figure 3 shows the government's expectation of a more than three-fold increase in supply between 2010 and 2020 (more than six-fold over the whole period depicted).

Figure 2. Relative importance of biomass feedstocks for heat and electricity use in the UK in 2009 (in ktoe)



Source: DECC statistics[8]. Acronyms: MSW is municipal solid waste, ktoe is kilo (thousand) tonnes of oil equivalents. The figure shows the relative importance of bioenergy feedstocks on a fuel input basis for both heat and electricity generation (all converted to ktoe), giving a total of 4.54 Mtoe (million toe).

Figure 4 gives an indication of the biomass potential in the UK, by feedstock, based on the most recent estimates available, produced by AEA in conjunction with Oxford Economics and Forest Research (Howes *et al*, 2011) for DECC[9]. To our knowledge this is the most recent of a number of estimates of the relative importance of different domestic biomass feedstocks and is based on a number of consistent assumptions. For this reason we take it as a helpful articulation of current technical and policy

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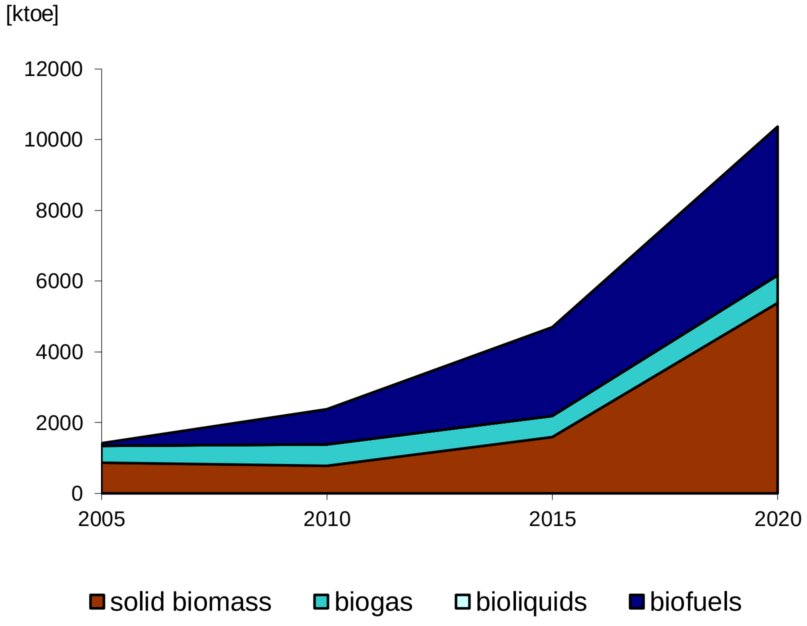
[7] The 6.09 Mtoe would make up around 30 per cent of total renewable use in 2020 as anticipated in the NREAP. Taking all bioenergy into account, including imports (most notably of biofuels), increases the share to around 50 per cent. Another comparator: The 6.09 Mtoe would represent just over 4 per cent of the UK's anticipated gross final energy consumption (excluding aviation) in 2020 or just over 11 per cent of its gross final energy consumption in the heating and cooling sector.

[8] See annual tables 'Digest of UK energy statistics', Renewable sources used to generate electricity and heat; electricity generated from renewable sources (DUKES 7.1.1), available at http://www.decc.gov.uk/en/content/cms/statistics/source/renewables/renewables.aspx.

[9] An earlier attempt to estimate the UK bioenergy potential is contained in the UK Biomass Strategy (Defra, 2007).

assumptions. However, we must emphasise that there is room for different judgements on the potential role of different supplies for instance in relation to the extent of energy recovery from waste. We do not view the potentials estimated by Howes *et al* as necessarily sustainable *per se* and no estimate can be considered authoritative given current levels of uncertainty. We have also drawn on the work of Gove *et al* (2010) who collated estimates from various sources. Potentials of this kind can be exploited in a sustainable way only in the presence of environmental safeguards and of a policy framework that pursues the efficient use of biomass resources, as the report maps out.

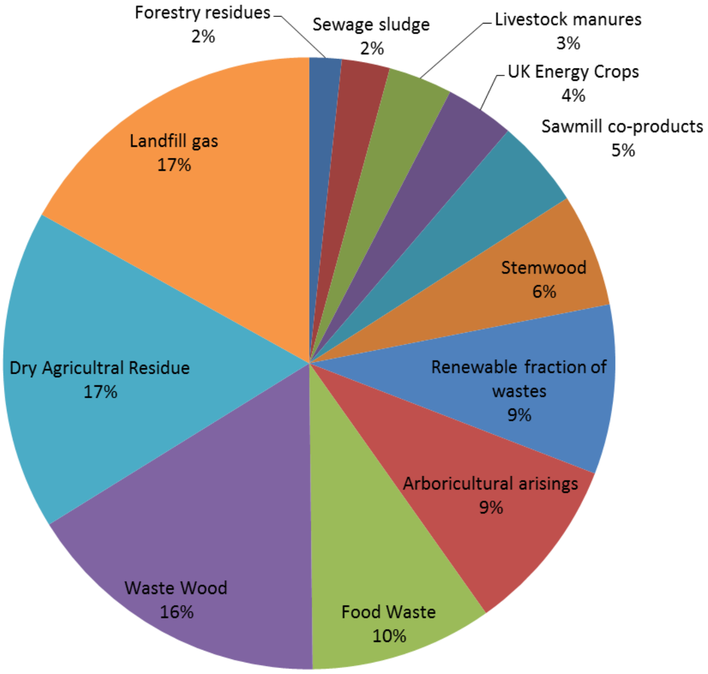
Figure 3. Bioenergy consumption pathway according to the UK NREAP



Source: Atanasiu (2010). The data refer to gross final bioenergy consumption including domestic and imported bioenergy as contained in the UK NREAP.

The level of overall bioenergy supply and the share of different sources in the total are both sensitive to the price that producers can expect. Higher market prices, reflecting increased oil prices for example, can be expected to increase supplies of bioenergy, particularly for those sources with more elastic supply chains. This is well illustrated in the work of Howes *et al* (2011) who model a range of possible scenarios for UK (and global) bioenergy supply. The scenarios differ in the biomass feedstock price level assumed and the extent to which a set of postulated constraints is overcome. In addition to this, there are two alternative sets of scenarios in relation to the usage of available land for energy crop production. One scenario maximises the cultivation of first generation biofuel feedstocks and the other maximises the production of woody energy crops. For the year 2020, there is no major difference in the supply mix between the two alternative scenarios, because up to then energy cropping is limited 'by the rate at which energy crops can be planted rather than the amount of land available for energy crops' (Howes *et al*, 2011, p19). Constraints taken into account include market conditions, policy and regulations, as well as technical and infrastructure limitations. Three alternative bioenergy price levels are modelled, £4, £6 and £10 per GJ. The price of £4/GJ represents the current price of bulk chips. The price of £6/GJ is seen as a 'more realistic estimate' for the short to medium term price level and is therefore adopted for illustration in Figure 4 (Howes *et al*, 2011, p7). The various scenarios constructed show that agricultural residues, waste wood and landfill gas are expected to dominate bioenergy supply in the UK over the next decade (disregarding first-generation biofuel crops). The latter is the only resource that decreases over time (2010 to 2030) due to reduced volumes of landfill waste.

Figure 4. The UK Biomass potential in 2020 and the relative importance of different feedstocks

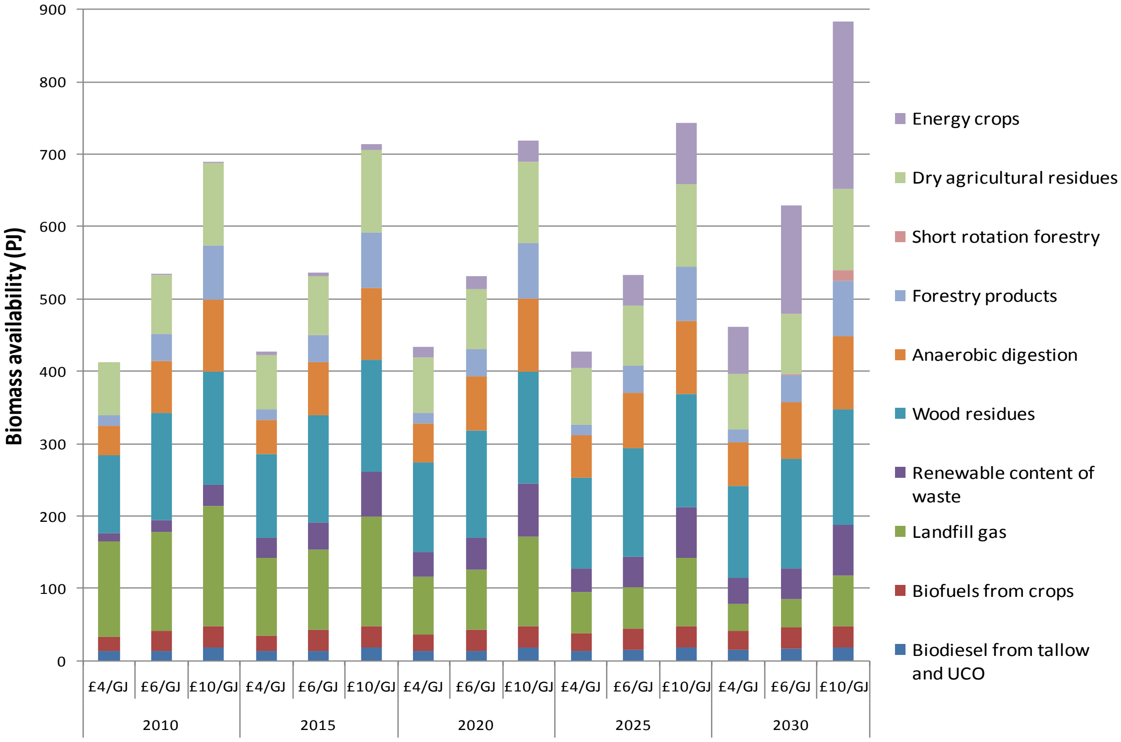


Source: Howes *et al* (2011). The data in the figure are from a scenario estimating the constrained potential at £6/GJ overcoming easy and medium constraints for the year 2020. The total potential thus estimated is 488 PJ equating 11.7 Mtoe.

According to this exercise, energy crops could make up a significant part of the UK bioenergy resource by the year 2030 under the scenarios involving maximised energy crop production, as displayed in Figure 5. Figure 5 displays the effect of altering the assumptions on feedstock price levels and on certain constraints overcome as well as changes in the relative competitiveness of feedstocks over time. Significant changes in supply over time are the decrease in landfill gas and the increase in land available for bioenergy crops due to increases in the yield of agricultural crops as a whole (more details on assumptions in section 4.5.1). As an example, Figure 5 shows that bioenergy from short rotation forestry would only be available in 2030 in the presence of high feedstock prices and success in overcoming various 'hard', effectively challenging constraints. The figure displays the range of uncertainty that is underlying estimates of potential, a fact recognised by the authors who advise the estimates to 'be used as a guide, rather than regarded as absolute certainty' (Howes *et al*, 2011, p6).

While current bioenergy use relies on waste resources to a considerable extent, it is the anticipated scale up, together with plans to increase biomass supply from woodfuel and energy crops that warrants discussion, alongside the anticipated high dependence on imports.

Figure 5. The UK Biomass potential under different price and constraint assumptions



Source: Howes *et al* (2011, p22). Summary of results under the assumption that production of energy crops on available land is maximised. The following pairs of price level/constraints overcome are represented: £4/GJ and no constraints met, £6/GJ and easy and medium constraints met, and £10/GJ and all constraints met.

2.2 The scale of anticipated UK bioenergy imports

The UK currently imports a substantial proportion of its bioenergy supply and there is a range of questions about the provenance and sustainability of many of these[10]. Furthermore, there are grounds for expecting import levels to grow substantially in the coming years. In 2007, the Biomass Strategy (Defra, 2007) stated that '[imports] of biomass, biofuels and biofuel feedstocks play an important role in meeting current UK demand and will continue to do so' (p19). According to the Biomass Strategy, 54 per cent of all biomass co-fired in electricity generation in 2005 was imported. According to DECC's Renewables and Waste Commodity Balances 2009[11], imports in 2009 made up 36 per cent of 'Straw, SRC, and other plant-based biomass' primary

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[10] See ENDS (2011b) reporting on the low uptake of UK sourced biomass in co-fired power plants.

[11] See annual tables 'Digest of UK energy statistics', DUKES 7.1, available at http://www.decc.gov.uk/en/content/cms/statistics/source/renewables/renewables.aspx.

energy supply and 78 per cent of liquid biofuel supply, leading to an overall 16 per cent share of imports in total renewable supply (due to a large share of liquid biofuels in total UK renewable supply in 2009). Looking ahead to 2020, on the current trajectory, imports could account for about 40 per cent of total supply, 6.09Mtoe out of the 10.4Mtoe, suggested by NREAP data and shown in Figure 3.

This apparent shortfall in domestic supplies has yet to be mapped out very clearly, however. The UK NREAP does not explicitly make precise predictions about the future share of biomass imports in meeting the UK's renewable energy targets. It is stated only 'that there could be sufficient biomass resource potential in the UK to meet this [ie bioenergy] demand for heat and power in 2020 [... assuming] that we could rapidly increase the production of energy crops in the UK, increase wood fuel supply from sustainable forestry, make better use of agricultural residues and fully exploit waste biomass currently going to landfill.' In this context reference is made to the Forestry Commission's Woodfuel Strategy for England. This has the goal of delivering an additional two million tonnes of woodfuel annually by 2020. In principle, this would be achieved by improving woodland management; the amount of additionally sourced forestry energy would constitute around 2 per cent of the UK's 2020 renewable energy need. At the same time, however, the NREAP states that '[imported] biomass products are likely to continue to play a role in the UK's use of bioenergy' (UK NREAP, p138). Independent work commissioned by DECC is more explicit in pinpointing the likely scale of import dependence. Howes *et al* (2011) have estimated global bioenergy supply and, demand and based on assumptions on the amount of global supply reaching the UK market, expect that domestic feedstocks will make up only one third of the potential bioenergy supply in 2020 falling to 10 per cent in 2030 (due to increased global energy crop supplies).

The scale of future UK bioenergy imports is not transparent from the NREAP report but is clearly expected to be large. It needs to be confronted squarely. Given the lack of information about the provenance of future imports and the nature of their production chains there are legitimate reasons for serious concern about their sustainability. The exploitation of domestic bioenergy sources by contrast has the merit that their environmental impacts are more readily observed, better understood and more easily regulated. For this reason it is much more secure to focus bioenergy strategy on domestic supplies. The main reasons for concern about the sustainability of imported biomass including bioliquids for electricity generation are the absence of environmental safeguards in many of the supply zones or a lack of effective enforcement and poor monitoring of production standards along the supply chain. For example, recent research based on satellite images suggests that a fifth of tropical carbon-rich peatland forests in Malaysia and Indonesia have been clear felled or converted to oil palm plantations by 2010 (ENDS, 2011a). Palm oil is used in many industrial processes, *inter alia* as a bioliquid in electricity generation and as biodiesel in transport. A strategy based less on imports would be far more robust in environmental terms.

3 ENVIRONMENTAL RISKS AND BENEFITS OF BIOENERGY

Ensuring that bioenergy production in the UK indeed delivers environmental benefits that relate to but also go beyond the delivery of climate and energy objectives requires environmental considerations to be taken into account at every stage of the production process. Different forms of bioenergy entail substantially different environmental impacts and to reflect this some forms of bioenergy should be prioritised over others in order to create an environmentally responsible UK bioenergy sector. The current policy framework drives lower cost renewable energy solutions as a priority while the costs related to potential negative side effects on the environment often are not accounted for. The key issues are summarised in this section.

3.1 Key Environmental Issues

Greenhouse gas emissions: Bioenergy is promoted as a low-carbon energy source. This makes the reduction of lifecycle greenhouse gas emissions a minimum requirement for any bioenergy development. In establishing the impact on GHG emissions it is essential to take into account the efficiency of bioenergy production plants (efficiency of conversion) and the production methods and location of the biomass resource capturing the impact on soil carbon, sequestration and payback times of the emissions from growing the feedstock and any relevant land use change. Work by the Environment Agency (2009) has demonstrated the importance of following good practice in the cultivation, processing and conversion into energy end-products of biomass feedstocks in order to achieve significant greenhouse gas emission reductions. It has rightly emphasised that land use change has the potential to negate any savings achieved from using biomass and shown that using waste products can lead to very substantial emissions savings. It is difficult to ensure that supplies with unfavourable lifecycle balances do not enter European supplies given the nature of international commodity markets.

The use of waste products rather than those from certain other sources, such as forests has a further advantage. It can reduce the build up of ***carbon debts*** that can be associated with bioenergy use, particularly when bioenergy is sourced from an existing forestry resource. Burning biomass releases carbon dioxide. However, in the energy sector the bioenergy combustion process is considered carbon neutral in bioenergy emissions lifecycle accounting. This is based on the logic that the CO_2 released will be recaptured again from the atmosphere during plant growth. However, using biomass from existing forests, which represent large carbon sinks, as an energy source can for instance lead not only to a decrease in the forests' capacity to sequester carbon emissions, but also to depletion of the carbon stocks in that forest and therefore of actual carbon storage at the time. As such it can lead to an increase in emissions today that will only slowly be sequestered and stored over time by regrowth. In some instances this time can be very significant with forests taking decades or even centuries to reach the same level of carbon stored before the release into the atmosphere at the time of combustion (ie repaying the carbon debt).

A large reliance on certain forms of bioenergy to meet renewable energy targets today therefore has the potential to lead to global CO_2 emissions from land use, land use change and forestry (LULUCF) activities substantially reducing carbon sinks. Though national accounting for emissions and removals from LULUCF activities is partly mandatory under the Kyoto Protocol – with respect to afforestation, reforestation and deforestation – land management activities such as forest management, cropland management, revegetation and grazing land management are only optional. Where countries choose not to account for those activities, emissions from bioenergy combustion related to forest management activities would be ignored. The emissions are currently not picked up in the energy sector as IPCC guidelines[12] stipulate that the emissions should be captured in the AFOLU (Agriculture, Forestry, and other Land Use) sector. The question of making LULUCF accounting mandatory is part of the current UN climate negotiations. These negotiations are expected to lead to a decision on how exactly LULUCF activities will be accounted for. New proposals for LULUCF rules being negotiated under the UNFCCC still risk failing to fully account for forest management emissions with the quantity of unaccounted emissions depending on the definition of the base year. If at the time of reference, forests were already managed for bioenergy combustion only the increase since that base year will be taken into consideration. Furthermore any biomass sourced from countries not signed up to the Kyoto Protocol such as the US and developing countries will automatically be accounted as carbon-free.

The lack of full global, mandatory LULUCF accounting rules under the Kyoto Protocol therefore creates a sizeable risk that those governments seeking to account a reduction in GHG emissions will seek recourse to bioenergy pathways from forests, partly because of their favourable treatment in accounting terms, with insufficient regard for the carbon debt problem and unaccounted emissions. The accumulated size of the potential carbon debt and failure to capture missing emissions in LULUCF accounting is challenging. There has been research that shows that, depending on the bioenergy pathway and the fossil fuel comparator, it may take several decades for bioenergy use to lead to an actual reduction in CO_2 emissions into the atmosphere[13]. The European Commission is expected to decide in the second half of 2011[14] whether to include LULUCF activities in the EU's GHG emission reduction commitment in parallel to the current UN climate negotiations The fact that these issues are unresolved at the moment and the risk of incomplete accounting of emissions highlighted above makes a strong case for prioritising the exploitation of bio-waste resources over carbon fixing forests.

Biodiversity: The top priority under the biodiversity heading is to minimise any harm to biodiversity and ecosystems, that could occur from bioenergy exploitation

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[12] IPCC Guidelines for National Greenhouse Gas Inventories: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[13] See McKechnie *et al* (2011) for a recently published paper on this issue.

[14] http://ec.europa.eu/governance/impact/planned_ia/docs/2011_clima_008_lulucf_en.pdf

through direct or indirect habitat conversion (eg from semi-natural grasslands to energy crops) or from management intensification (eg deadwood removal in ancient woodlands). However, there is also scope for achieving positive biodiversity co-benefits from appropriately planned and managed biomass production. In particular, there appears to be considerable potential for improving the ecological condition of many broadleaved woodlands through appropriate sustainable wood fuel production, as some 60 per cent of Britain's ancient semi-natural and other semi-natural woodlands are currently undermanaged[15]. The lack of management is leading to detrimental impacts on a range of woodland species (Kirby *et al*, 2005; Fuller *et al*, 2005; Currie, 2006; Ellis, 2006; Robinson, 2009). Some heathlands and grasslands are also currently suffering from under-grazing (Townshend *et al*, 2004; English Nature, 2005) and are therefore threatened by relatively unrestrained scrub development. Where tree and scrub removal is required, the costs of such nature conservation focussed management could be supported to some degree through sales of wood fuel.

There is also the potential for biomass production to reduce pollution impacts on biodiversity. For example, diffuse nutrient pollution from agriculture is a significant pressure on many water bodies (Townshend *et al*, 2004; Mainstone *et al*, 2008), but in selected locations this could be mitigated by the conversion of intensive agriculture land uses to energy crop production systems that have lower levels of fertilizer and pesticide inputs and that reduce soil erosion (through the creation of long-term vegetation cover).

Efficient resource use: Bioenergy development should be oriented towards making the most efficient use of the biomass resource available so as to balance resource needs for energy with other demands for biomass ie food and fibre, to deliver the greatest GHG saving potential where biomass is used for energy and to contribute to environmentally responsible management of bio-waste. There is a close linkage between bioenergy use and demand for finite land supplies. Increased use of bioenergy may trigger direct and indirect land use change crowding out other uses of land and leading to emissions from land use change that have the potential to reverse the emission savings from bioenergy use. The problem of indirect land use change (ILUC) has been demonstrated in relation to first generation biofuels but applies more generally any bioenergy crops that require land[16].

Water quality and availability: An often overlooked factor in the bioenergy discussion is water. Agriculture already places substantial demands on water resources and bioenergy development will potentially increase the strain on the water resources in some regions, in the East of England for example. Consequently,

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[15] Rob Green, Natural England, pers. comm. 2011.

[16] See Bowyer (2011) for a study on potential land use change and emission impacts from indirect land use change. The main finding of the study which is based on projections taken from Member States' NREAPs is that indirect land use change, if not mitigated by appropriate legislation, will lead to increased emissions from biofuel use as compared to those from fossil fuel use. Kretschmer (2011) discusses some of the modelling work conducted to quantify indirect land use change and argues for the ILUC debate to be broadened to encompass the wider impacts of agricultural and other land using activities.

it must be ensured that production is in line with the available water resource, avoiding negative impacts on water availability and increased conflict for water between bioenergy development and other uses of water. This may be an issue in parts of the UK and even more so at a global level.

Air quality: Significant air pollution can arise when biological materials are combusted unless the appropriate technologies to limit emissions are used. Some limited sulphur (SOx) emissions occur from biomass combustion; however, these are of relatively minor concern, especially when bioenergy replaces oil and coal combustion. Particulate emissions are a potential air quality problem. Key determinants are combustion temperatures and the material being burned. Solid biomass carries the greatest risks. Particulate control has improved in recent years through more advanced techniques. However, small particulates remain a concern for local air quality and particulate waste captured in pollution control measures has to be treated appropriately due to toxic contaminants, which represents a further waste management stage. NOx emissions are more difficult to handle and they occur as a result of the combustion process no matter what is being burned. Advanced combustors reduce NOx emissions to a minimum but the investment costs can be high, especially for small-scale applications. Placing small-scale bioenergy plants in rural areas with low ambient NOx levels usually will not create significant local NOx related pollution. All in all, the burning of biomass or its use in anaerobic digestion will most likely be beneficial for air quality when it replaces coal combustion. The case is less strong in those cases where oil is being displaced; biomass replacing natural gas is likely to lead to increased pollution (Defra, 2007).

3.2 A Sustainability Hierarchy for Bioenergy Sources

Consequently, it is important to make a thorough assessment of the sustainability of domestic biomass resources and the scope for utilising them on a larger scale. Given the significance of the environmental sensitivities outlined above it is helpful to introduce a sustainability hierarchy into any plans or strategies to exploit domestic resources, rather than seeking to utilise the lowest cost resources first, the route followed in most forms of energy supply. While costs are clearly important, a sustainability hierarchy provides a good foundation for a strategic approach to exploiting bioenergy as part of a robust UK renewable energy policy and developing appropriate policy tools to implement it.

Recent work by Gove *et al* (2010) has offered a hierarchy of biomass feedstocks used as energy sources in the UK, partly for this purpose. We adopt their hierarchy here in a slightly modified and simplified form[17]. The hierarchy incorporates the principles

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[17] We have reduced the number of categories from six to five by omitting the category ‘Agriculture and plantation co-products and by-products’. Gove *et al* (2010) do not provide a clear definition for this category and our modified ranking encompasses all feedstocks of major importance. We rename the category ‘non-waste wood’ to ‘Biomass harvested from multifunctional woodlands (existing and newly created)’ and rank it above ‘Dedicated energy crops’. This is to reflect the undesirability of large scale plantations of eg miscanthus and short rotation crops/forestry versus the multipurpose of

put forward by the Environment Agency in their recent work (2009a/b). If implemented it could be expected to deliver environmental benefits beyond greenhouse gas savings most notably to contribute to meeting UK biodiversity policy goals, such as those set out in the Biodiversity Action Plan.

We therefore rank bioenergy feedstocks in the following way, starting with the most beneficial feedstocks in environmental terms:

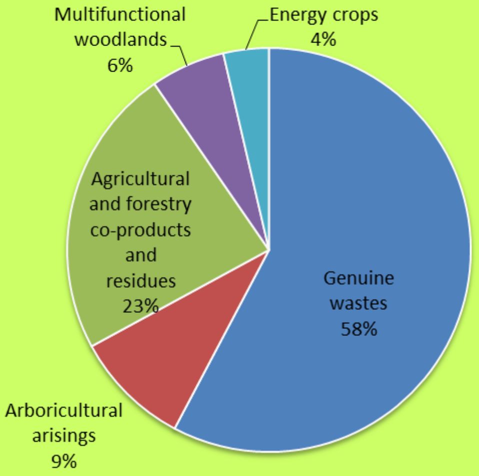
(1) Genuinely residual wastes;
(2) Arisings produced by habitat conservation and landscape management;
(3) Agricultural and forestry residues;
(4) Biomass harvested from multifunctional woodlands (existing and newly created);
(5) Dedicated energy crops (excluding biofuels).

These are five categories make useful building blocks for a general hierarchy for the efficient use of biomass but, to make it operational, some further development would be needed. In particular it would be necessary to distinguish between different categories of waste and to identify when the relevant categories are best used as energy rather than as materials in other processes or in the restoration of soil (via composting).

4 BIOENERGY FEEDSTOCKS: POTENTIALS AND CURRENT POLICY FRAMEWORK

The UK's bioenergy resource within the hierarchy

	PJ	Mtoe
Genuine wastes	282	6.77
Arboricultural arisings	46	1.09
Agricultural and forestry residues	114	2.73
Multifunctional woodlands	29	0.70
Energy crops	18	0.43
Total	**488**	**11.71**



Source: The diagram summarises the estimates of potential from Howes *et al* (2011) whose estimates also underlie Figure 4, but this time grouped aggregated to fit the biomass feedstock hierarchy.

Taking the ranking of the biomass hierarchy introduced above as a foundation, the following subsections introduce the different feedstock options and their potential,

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woodlands providing timber for various markets as well as recreational and biodiversity value if managed appropriately.

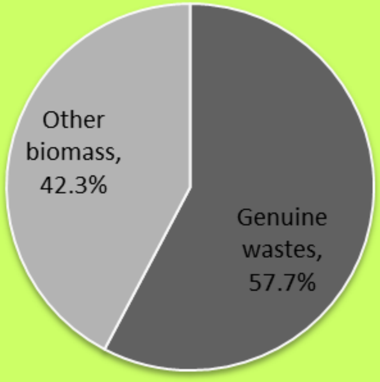
taking into consideration environmental challenges and the current policy framework. An overview of the potential scale of the UK's bioenergy resource in 2020, split into the five categories of the hierarchy, is shown in the diagram below. It can be seen that two categories, genuine wastes and residues from farms and forests, represent about three quarters of the total.

4.1 Genuinely residual wastes

Genuine waste resources – 2020 estimate

	PJ	Mtoe
Genuine wastes	282	6.77

Sewage sludge	2.5%
Livestock manures	3.4%
Renewable fraction of wastes	9.0%
Food Waste	9.6%
Waste Wood	16.3%
Landfill gas	16.9%



Source: Based on estimates of potential from Howes *et al* (2011).

Genuine waste products comprise wastes that are not easily avoidable, such as sewage sludge, livestock residues and slurries, some food waste, non-recyclable/compostable municipal solid waste and some wood and paper waste. As a starting point the use of waste as a resource for energy should not compete with wider resource efficiency objectives such as the conservation of natural resources and the efficient use of biomass for crucial uses such as rebuilding soil carbon. Thus municipal and business waste streams must be treated in accordance with the waste hierarchy which prioritises prevention, reuse and recycling/composting above energy recovery and prioritising all of these options over ultimate disposal to landfill. Keeping this in mind, negative environmental impacts from using waste for energy can be minimised as long as pollution deriving from the storage, transport and processing of waste resources is prevented. The use of waste for energy purposes can provide environmental benefits by reducing disposal to landfill and potentially reducing the need for land-derived biomass. For many wet wastes (sewage sludge, animal slurry, food waste), anaerobic digestion is likely to be the most efficient end-use option. For dry wastes (non-recyclable/compostable municipal solid waste, waste wood), either blending with wet sources for anaerobic digestion or use for generation of heat and power are reasonable end uses (see Gove *et al*, 2010).

The use of bio-waste for energy production would contribute to the more environmentally responsible management of this material. Composting produces a useful, high-quality product, but some biodegradable wastes (e.g. cooked kitchen waste and animal by-products) are not suitable for windrow composting. Such wastes can be processed through anaerobic digestion (AD), which produces biogas that can be burned to generate heat or electricity, together with digestate (a solid and liquid residue) that can be used as a soil conditioner to fertilise land. Both composting and anaerobic digestion (AD) can significantly reduce GHG emissions. A report by ERM (2006) states that AD provides higher net carbon savings than composting; 5.5 million tonnes of food waste treated by AD could generate between 477 and 761 GWh of electricity annually (this would meet the needs of up to 164,000 households) (Hogg *et al*, 2007). Compared to composting the same amount of food waste, treatment with AD would save between 0.22 and 0.35 million tonnes of CO_2 equivalent (assuming the displaced source is gas-fired electricity generation) (ERM, 2006). Both composting and AD have a clear role in a sustainable waste policy.

4.1.1 Potential

The potentials outlined below suggest considerable potential for waste to contribute to energy production; this is true for the time being, but it must be assumed that some forms of waste will not continue at current levels due to ongoing efforts to prevent waste. Figure 4 shows that the different forms of waste resources could make up more than half of the total UK bioenergy potential. According to figures from Defra (2007), the UK produces around 100 million tonnes of waste suitable for AD each year although the relative contribution of manure to this total varies between studies.

The UK generates an extremely large amount of **food waste**; WRAP[18] estimates that around 8.3 million tonnes per year of food and drink waste is generated by UK households (equivalent to 330kg per household per year, or just over 6kg per household per week), and that the amount of food wasted per year is 25 per cent of that purchased (by weight). Around 5.8 million tonnes per year (70 per cent) of household food and drink waste is collected by local authorities, mainly in the residual waste stream and food-waste kerbside collections, offering some opportunity to capture the waste stream. Box 1 reports on improved waste separation efforts in a London Borough. A recent study for the European Commission[19] estimates that the UK had both the highest absolute generation of food waste (8.3 million tonnes, 22 per cent of the EU-27 total) and the highest per capita generation (approximately 137kg, compared to an EU-27 average of just below 64kg) in 2006[20]. It is therefore fair to assume that future prevention efforts could significantly reduce the availability of food waste as a bioenergy feedstock in the UK, potentially halving it just by attaining average EU food waste levels.

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[18] WRAP, Household Food and Drink Waste in the UK, November 2009, http://www.wrap.org.uk/downloads/Household_food_and_drink_waste_in_the_UK_-_report.b5433206.8048.pdf.

[19] Food waste report through DG ENV SRM FWC – full report: http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf.

[20] Calculation based on data from Food waste report through DG ENV SRM FWC – full report: http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf and Eurostat total population data.

Research by Tristram Stuart (2009) suggests that twice as much carbon saving can be made from using food waste for animal feed compared to AD (and if land use change from feeds is taken into account, it is very much more. However, this practice has largely ceased and health related regulations, particularly the EU Animal By-Products Directive currently forbids the use of food waste for animal feed.

Box 1. Waste Separation Scheme, London Borough of Bromley

In 2008, Bromley introduced a trial scheme to collect food waste separately and increase the frequency of paper collection. In its final stage, the trial covered 27,500 properties, with food waste and paper collected every week and residual waste, glass, cans and plastics collected fortnightly. Results included an 11 per cent reduction in overall waste generated and a 45 per cent reduction in residual waste being collected. All separately collected biodegradable waste was sent for recycling or energy production, representing an increase in kerbside recycling from 24 to 52 per cent. October 2010 saw the scheme rolled out across the borough, and Bromley is predicting a household recycling rate above 55 per cent as a direct result.[21]

Sewage sludge provides a constant, reliable source for bioenergy (case studies in Box 2). According to Centrica[22], the average person produces 30kg of dried-out sewage sludge per year that could be used for producing gas. This means that the UK population (62.5m) could theoretically generate enough renewable gas to meet the annual demand of 200,000 homes, or around one per cent of the UK population. In practice, however, it is not viable to fit all 9,600 sewage treatment facilities in the UK with the necessary technology, as some only treat sewage from a very small number of people. Figures from Water UK[23] suggest that around 66 per cent of the 1.6 million tonnes of sewage sludge produced annually by the water industry is treated by AD, with 60 per cent of the resultant biogas being used to generate renewable heat and power by CHP engines. The use of sewage sludge for energy production has considerable potential. Not only is it a reliable feedstock, its use for this purpose also helps to reduce the environmental impacts of this type of waste (eg by diverting organic waste from landfill and reducing methane emissions). The water industry has long experience of using AD to treat sewage and produce energy, and water companies already operate (and continue to invest in) related assets worth hundreds of millions of pounds. There is considerable potential for this capacity and experience to be more fully exploited, particularly if more certainty can be achieved on how to regulate mixed waste streams, and improved incentives can be provided to encourage appropriate levels of investment.

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[21] HM Government Carbon Plan, March 2011, http://www.decc.gov.uk/assets/decc/What%20we%20do/A%20low%20carbon%20UK/1358-the-carbon-plan.pdf.

[22] Centrica plc, ‘Sewage project sends first ever renewable gas to grid, 5 October 2010, http://www.centrica.co.uk/index.asp?pageid=39&newsid=2080.

[23] Press release: Water industry shows the way in turning waste into energy and fertiliser, Water UK, 15 July 2009, http://www.water.org.uk/home/news/press-releases/defra-anaerobic-digestion.

Box 2. Didcot sewage works

In October 2010, the Didcot sewage works in Oxfordshire started to feed biomethane produced from human waste into the gas grid for the first time. The landmark project (run by Thames Water, British Gas and Scotia Gas Networks) will produce enough renewable gas to supply up to 200 homes. The sludge from sewage that arrives at the Didcot works is treated by AD to yield biogas, and impurities are then removed from the biomethane before it is fed into the gas grid. The whole process – from flush to gas being piped to people's homes – takes around 20 days. The project took six months to complete and cost £2.5m.

Thames Water already produces on average £15m a year of electricity by burning biogas from the 2.8bn litres of sewage produced daily by its 14m customers. It regards feeding the renewable gas directly into the gas grid as a logical next step in its energy from waste activity. British Gas has stated that gas from sewage is just one part of a bigger project that will see the company using brewery and food waste and farm slurry to generate gas to heat homes. According to a study by National Grid, biomethane could account for at least 15 per cent of the domestic gas market by 2020, making an important contribution to decarbonising the gas grid by delivering renewable heat to households through the existing gas network and central heating boilers.

Reading Sewage Treatment Works[24]

Officially opened in 2005, the £80 million Reading Sewage Treatment Works treats wastewater for 284,000 people. It features four 20-metre-high egg-shaped digesters that form part of a CHP process in which methane is burned to drive an engine, creating energy. The electricity generated provides 48 per cent of the electricity needed at the site (equivalent to the electricity consumed by 1,300 homes or 3,277 tonnes CO_2e). In addition, the exhaust heat from the electricity generation plant is captured and used to pasteurise the sewage sludge so it can be used as agricultural fertiliser.

According to the UK NREAP, it has been estimated that in 2009 about 6 million tonnes of **waste wood** were sent to landfill each year. This amount could be significantly reduced, and Defra is funding ongoing research into the most environmentally sound options for waste wood. This research, led by AEA Technology, is reported to have indicated that landfill is one of the worst options in environmental terms, resulting in methane emissions, whereas options that end in energy recovery often with a form of reuse as an interim steps are better environmentally and deliver 'significant' carbon savings[25]. The best option for waste wood, however, is reuse (for example in the case of furniture) or recycling where possible. Higher value can be extracted from clean untreated waste wood for non-energy uses (such as animal bedding) and waste wood can be used in the paper/pulp industry, and thermal processing of contaminated wood waste poses significant risks

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[24] Thames Water, Reading Sewage Treatment Works, http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/5671.htm.

[25] Letsrecycle.com, 'Significant' benefit in using waste wood as fuel, 30 November 2010, http://www.letsrecycle.com/do/ecco.py/view_item?listid=37&listcatid=5687&listitemid=56801&section=wood.

in terms of pollutant emissions. Question marks therefore remain over whether energy processing can be regarded as an option that provides adequate economic or environmental benefits.

4.1.2 Current Policy

Existing **UK legislation**[26] on waste follows the approach developed at the EU level, prioritising movement up the waste management hierarchy. For example, England, Scotland, Wales and Northern Ireland must each have a strategy for reducing the landfilling of biodegradable waste (defined as any waste capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste and paper and paperboard), including measures to achieve the landfill reduction targets by recycling, composting, biogas production, materials recovery or energy recovery. This is born out of the EU Landfill Directive, which requires that the UK reduce biodegradable municipal waste sent to landfill to 75 per cent of 1995 levels by 2010, 50 per cent of 1995 levels by 2013, and 35 per cent of 1995 levels by 2020. The landfill tax, which began in 1996 at a rate of £7 per tonne of waste sent to landfill, currently stands at £48 per tonne (for 2010/11) and will reach £80 per tonne in 2014, is clearly targeted at reducing the amount of waste sent to landfill. As recognised by the UK Renewable Energy Strategy (DECC, 2009), the tax therefore 'provides a powerful driver to divert waste from landfill to other uses'.

It is clear from the key objectives and targets on waste that the emphasis should be on waste prevention and re-use, increasing recycling and composting and diverting waste from landfill. Increasing the recovery of energy from residual waste is only one aim of waste policy, and care must be taken to ensure that it is not pursued to the detriment of the other objectives and targets.

In June 2011, Defra published its **Government Review of Waste Policy in England 2011**. The Review[27] addresses all aspects of waste policy and delivery in England, with the aim of ensuring that the right steps are being taken towards creating a 'zero waste' economy, where resources are fully valued. Once again, in essence this means trying to move waste management up the waste hierarchy. The Review does not make recommendations on preferred technologies (which include direct combustion (incineration), gasification, pyrolysis, and AD) as choice of technology depends on the type of waste available, local circumstances and finance.

On food waste specifically, the Review highlights prevention as the top priority; it is suggested that each tonne of food waste prevented avoids 4.2 tonnes of CO_2 equivalent emissions (compared with landfilling). AD is presented as the food waste treatment option with the greatest environmental benefit (avoiding 500kg of CO_2 equivalent emissions compared with landfilling), followed by composting and then incineration with energy recovery. The Review highlights the need for food waste to

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[26] Waste and Emissions Trading Act 2003, http://www.legislation.gov.uk/ukpga/2003/33/part/1/chapter/1.

[27] Defra, Waste Review, http://www.defra.gov.uk/publications/files/pb13540-waste-policy-review110614.pdf

be collected separately at source in order to be treated by AD. On energy recovery from waste more generally, the Review states that the aim is ‘to get the most energy out of waste, not to get the most waste into energy recovery’. It states that ‘through effective prevention, re-use and recycling, residual waste will eventually become a finite and diminishing resource’, but also that projections to 2050 indicate that ‘sufficient residual waste feedstock will be available through diversion from landfill to support significant growth’ in energy from waste.

The **Coalition’s programme for government[28]** states that the Coalition will ‘work towards a ‘zero waste’ economy’, and ‘introduce measures to promote a huge increase in energy from waste through anaerobic digestion’. These ambitions form part of the government’s ‘Carbon Plan’. In late 2010, Defra published the Coalition Government's first draft AD action plan[29] and the final AD Strategy and Action Plan (DECC and Defra, 2011) has been published in June 2011 together with the Waste Review. It develops a ‘map’ of the current AD industry in England and its future potential (based on municipal, commercial and industrial waste streams). Its major aim is to address barriers to uptake and to this end proposes to improve dissemination of information, identify best practices, remove grid connection barriers, develop markets for digestates and investigate the use of biomethane as a transport fuel. It also announces a new loan fund of £10m (over four years) to be set up by WRAP. AD is also eligible for support under the feed-in tariff scheme and biogas/biomethane will be eligible for support under the Renewable Heat Incentive (see section 6 below).

Although it is clear that the intention of current and forthcoming waste policies is to encourage the use of residual waste for energy production (at least in preference to landfill disposal), it should also be noted that waste policy is increasingly focusing on preventing waste, which should result in a reduction in the availability of certain types of waste (perhaps most notably food waste) as an energy feedstock. Policy is also attempting to drive increased levels of recycling and composting, which should further reduce the levels of residual waste available for energy production. In addition, some forms of waste (notably wood) are potentially better used (in both environmental and economic terms) in other ways than for producing energy. Efforts to support energy from waste could therefore usefully focus on genuine wastes and those that are hard to reuse or recycle, most notably sewage sludge, livestock manure/slurry and the portion of food waste that is genuinely unavoidable.

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[28] The Coalition: our programme for government, May 2010, http://www.cabinetoffice.gov.uk/sites/default/files/resources/coalition_programme_for_government.pdf.

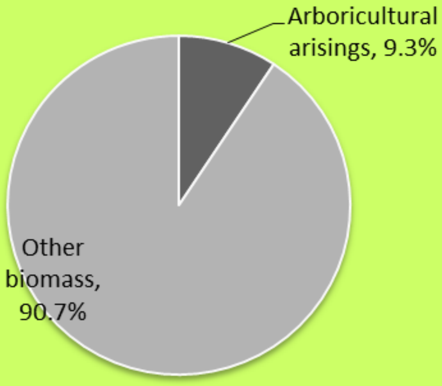
[29] Defra, Developing an Anaerobic Digestion (AD) Framework Document, http://www.defra.gov.uk/environment/waste/ad/documents/anaerobic-digestion-framework-101130.pdf.

4.2 Arisings produced by habitat conservation and landscape management

Arboricultural arisings resources – 2020 estimate

	PJ	Mtoe
Arboricultural arisings	46	1.09

Includes arisings from (following ADAS, 2008):
- Transport network
- Urban green space



Source: Based on estimates of potential from Howes *et al* (2011). Note that these figures include arboricultural arisings and do not explicitly refer to arisings from habitat conservation.

This feedstock category comprises a wide variety of vegetative material produced by management, improvement and restoration of domestic landscapes, green space and habitats primarily for the purpose of achieving biodiversity and/or landscape objectives. Nature conservation management can be expensive or difficult to fund and consequently many habitats tend to be undermanaged and potential restoration measures remain unrealised. Gove *et al* (2010) therefore suggest that the environmental benefits of the production of feedstocks that stimulate appropriate habitat management probably justify their use even when/if greenhouse gas balances are less favourable than for some other sources. Management for biodiversity can produce a regular supply of biomass with a range of uses (eg hay from species-rich meadows), but in cases where the management is irregular and the biomass of variable quality (eg scrub removal) it can be more likely to be treated as waste material, which usually has to be removed from site (because leaving it to decompose inhibits the desired habitat improvement).

Examples of **biomass from habitat management** include the removal of conifers from planted ancient woodland sites (PAWS) and from other semi-natural habitats, removal of invasive alien species such as *Rhododendron* from woodlands and Himalayan Balsam from water courses, removal of naturally regenerating scrub from heathland (before restoring grazing), mowing of species-rich grassland habitats (where grazing or hay-cutting is not viable), reed cuttings which cannot be used for thatch (see Box 3), and bracken cutting (where carried out as an alternative to chemical control). On farmland there will also be some material from annual mowing of grass buffer strips designed to prevent soil erosion (often on arable farms with no livestock), and from cutting vegetation on underused farmland as a requirement of CAP income support payments.

As noted above, according to Natural England some 60 per cent of Britain's ancient semi-natural and other semi-natural woodlands are undermanaged. This results in woodlands that tend to develop a uniform age structure with a dense canopy and few open spaces, which allows little light to the ground resulting in few seedlings, and a decline in ground flora species richness (Kirby *et al*, 2005). This has knock-on effects on associated fauna and can result in impoverished communities of birds (Fuller *et al*, 2005), butterflies (Ellis, 2006) and small mammals (Gurnell *et al*, 1992). Currie (2006) states that of the 31 Forestry Target Species for England, all but one are dependent on young-growth or old-growth woodland; the majority (18) are dependent on the former.

Consequently wood fuel production that results in thinning, the removal of alien species and, in appropriate situations, the reinstatement of coppice management and associated deer control could provide particularly widespread nature conservation benefits. However, measures would need to be taken to ensure wood fuel production is sustainable and management is beneficial for biodiversity, such that veteran trees and dead wood are retained and adequate stands are allowed to develop to maturity. Appropriate practices need to be determined on a case by case basis (no one-size-fits-all approach)[30]. It is necessary to guard against the danger of wood fuel management becoming too intensive, especially if demand and wood fuel prices rise, potentially leading to excessive removal of biomass, and possibly even-aged low diversity woodlands of fast growing exotic species, which would result in significant biodiversity losses. Furthermore, it is important to note that the restoration of neglected ancient and semi-natural woodlands, the particular biodiversity of which is dependant on continuation of longstanding management practices, and their subsequent management will produce a variety of woody biomass. However, there is no clear line to be drawn between arisings from woodland managed *solely* for biodiversity and the residues of multi-functional management of semi-natural woodlands broadleaf or mixed woodlands discussed in section 3.3 below.

Box 3. Biodiversity management of reedbeds taps the local market for bioenergy

A RSPB report (Melville, 2010) concluded that reed is (theoretically at least) a viable biomass fuel, but production costs are too high for it to be viable in today's market. In the UK it is currently only competitive when used for thatch, and management for biodiversity is currently funded by agri-environment programmes and conservation organisations, on the assumption that there is no market value for the material removed. The report cites an example from the Narew River valley, in north-east Poland, where a successful rural business produces briquettes for heating from reed and sedge cut from nature reserves. The removal of biomass from the wetland helps to maintain a suitable habitat for regionally valued birds by preventing the grasslands from becoming overgrown. These birds are returning to Narew National Park following a return of reed cutting. A farmer from the village of Zaczerlany seized the opportunity to harvest the reed as biomass to produce briquettes. During the winter of 2007/2008 he harvested 20 hectares of reed and sold the briquettes to local consumers and neighbouring farms. If the demand for heating materials made from reed increases, the area harvested will increase to 2,000 hectares.

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[30] The Forestry Commission England (2010) provides a compendium of guidelines and case studies.

There is also the potential to produce energy from **arboricultural arisings**, which include the material from tree surgery and other arboricultural operations on trees and shrubs grown primarily for their landscape and biodiversity value, on both private and public land (along transport corridors, urban streets and in parks and gardens). This material almost always is treated as waste and may be removed, composted, or chipped and left on site. Similarly, municipal authorities have to dispose of significant grass cuttings from publicly owned land.

4.2.1 Potential

The potential in this category is very difficult to assess. The sources are often small in area, geographically dispersed and intermittent, particularly in the case of habitat restoration where there may be a large quantity of biomass removed over a short period of time. The quality of the material may be unsuitable for existing processing technologies, which often require a steady supply of known quality and quantity. Material which is produced fairly regularly on an annual cycle would be used more easily, but in both rural and urban situations much of this is grass biomass that will only fully be exploitable for bioenergy purposes once second generation technologies are commercially available that can make use of this form of cellulosic material. Nevertheless current technologies such as AD could make use of at least some of this material, especially at a local scale.

The EEA (2006) pointed out that harvesting grass for bioenergy could provide some economic benefit for the management of species-rich grasslands, and thus prevent land abandonment and loss of valuable open habitats. It estimated that, at an EU scale, cuttings from grassland could contribute some 6–7 per cent of the estimated overall agricultural bioenergy potential. At a UK scale the DECC (2010) methodology[31] , for instance, does not include arboricultural arisings as the quantity may be difficult to assess; it will be partly sourced in private estates. The recent figures from Howes *et al* (2011) do include a potential for arboricultural arisings derived from ADAS (2008) amounting to 9 per cent of the total bioenergy potential. Arisings sourced from management exclusively for landscape and biodiversity purposes are likely to make up a small part of the overall potential, but nevertheless, could be locally important if accessible processing facilities and markets can be found.

4.2.2 Current policy

There are specific policies which encourage the production of these arisings, as a waste material. However, there are no specific policy initiatives directed at the use of this category of biomass, although some of it is likely to be captured by policies to encourage use of forestry and agricultural waste. For example, management of broadleaf woodland primarily for conservation purposes is supported with annual forest-environment payments through the Rural Development Programmes (RDPs)[32].

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[31] DECC (2010) provides a methodology addressed at English regions to estimate their renewable and low-carbon energy capacity.

[32] Measure 225, and to some extent measure 227, support for non-productive investment, under Regulation 1698/2005). For RDPs of all EU Member States, see:

The respective targets in the UK RDPs for woodlands covered under this measure for the period 2007-2013 are: 30,000ha for England, 700,000ha for Scotland and 500ha for Northern Ireland[33]. Nonetheless, it is impossible to estimate the quantity of arisings from biodiversity management in these woodlands, which represent only a small proportion of the woodlands targeted for multi-purpose management, including biodiversity.

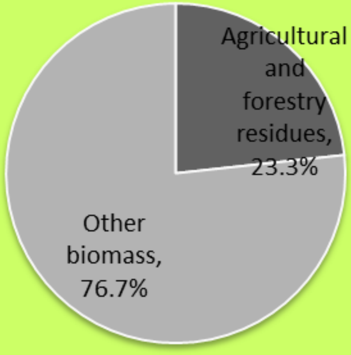
Agri-environment payments for biodiversity management of semi-natural habitats on farmland represent a significant proportion of expenditure on rural development measures on farmland in the UK. Only a part of the land concerned will be managed in a way that produces biomass arisings, because most of these farmed habitats will be grazed. The cost to the land manager of cutting and removing the unwanted biomass is normally covered by the agri-environment payments. If this source of biomass could be used in the energy sector, it could potentially reduce the cost of some agri-environment support, and of disposal in other cases, but it would require first overcoming significant problems in local supply chains (policy support for the supply chain is discussed below). Mobilising of biomass supply in this category might also be improved in large urban areas, eg by utilising municipal grass cuttings.

4.3 Agricultural and forestry co-products and residues

Agricultural and forestry co-products and residues – 2020 estimate

	PJ	Mtoe
Agricultural and forestry residues	114	2.73

Forestry residues	1.7%
Sawmill co-products	4.7%
Dry Agricultural Residue*	16.9%



*Mostly straw (¾), additionally seed hulls and husks and chicken litter

Source: Based on estimates of potential from Howes *et al* (2011).

This category includes co-products and residues arising from agricultural cultivation and forestry practices. Unlike the previous category, the use of these forms of biomass in the energy sector is not an outcome of conservation management but rather represents a way of making use of co-products and residues that accrue from primarily economic activities. The co-benefits for the environment are not

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http://ec.europa.eu/agriculture/rurdev/countries/index_en.htm. Background information: http://enrd.ec.europa.eu/rural-development-policy/introduction/en/introduction_home_en.cfm.

[33] Wales does not make use of measure 225 specifically, but instead has used investment grants under other RDP measures to support landowners to bring neglected woodlands back into management; no specific target is mentioned.

necessarily as pronounced as in the previous category and in some instances care must be taken to prevent negative impacts (such as would result from the removal of all wood and brash following tree felling).

Agricultural residues and by-products arise on a considerable scale and have significant potential as an energy source. Defra statistics show that their use has increased over the last decade compared to the 1990s[34]. However, they also have other uses in current and future farming systems and are not necessarily best deployed as an energy source. As an example, straw from cereal crops is commonly used as low cost animal bedding and as additional roughage in some livestock diets and only a portion is available as an energy source. Some agricultural residues can also provide environmental benefits. Residual straw can provide increased erosion control when some is left on the field surface after harvesting. In addition, the ploughing of some straw back into the soil can benefit soil structure (improving water infiltration and hence reducing surface runoff), reducing erosion, and increasing organic matter content. The value of this can vary considerably between soils. Future bioenergy development should utilise straw appropriately and be sensitive to the need to avoid diverting straw from more desirable uses within the agriculture sector. Being a by-product of arable farming, straw supply is not entirely stable but fluctuates in line with harvest yields with straw shortages and relatively high prices in some years. In addition, the supply (and thus potential) of straw varies across the country, depending on the main farming systems present.

Forestry residues such as those accruing from harvesting can be used for wood chips generating heat in larger scale boilers. Other forest residues include those emanating from the processing of timber such as sawmill residues. These can be processed into wood pellets, which are, because of their high quality, suited for different scale applications, including domestic boilers[35].

4.3.1 Potential

The potential of this category is sizeable. Dry agricultural residues make up 17 per cent of the estimated UK bioenergy potential. Sawmill co-products contribute a further 5 per cent and forest residues 2 per cent. The long term sustainable potential of dry agricultural residues, the bulk of which is straw with some additions from seed hulls and husks and chicken litter, is difficult to estimate given the numerous uncertainties involved. For example, there are some regions with straw shortages in the UK[36]. The increasing usage of straw for energy purposes must be closely

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[34] Note, however, that the source includes 'digestion of farm wastes' that we included in the category 'genuine wastes': http://archive.defra.gov.uk/evidence/statistics/foodfarm/enviro/observatory/indicators/documents/DD3.pdf.

[35] See eg Forestry Commission website: http://www.forestry.gov.uk/forestry/INFD-6GXL7N.

[36] A straw shortage has been found as part of the potential study for the South West (regen SW, 2010). The earlier Biomass Strategy (Defra, 2007) also attributed a similar considerable importance to the straw resource (18 per cent but in a different setting excluding the potential associated with landfill gas and first generation biofuel feedstocks) stating that its estimate represented a constrained potential that 'could be made available in the long term without disrupting livestock use/buying costs'.

monitored to prevent a diversion away from existing uses that could impact animal health and soil quality negatively.

4.3.2 *Current policy*

There are currently no policy driven incentives for the use of straw on fields or other practices which involve the re-ploughing of straw to improve soil structure. Although this is considered good practice in certain situations this is not necessarily the preference of farmers, who will be influenced by other factors as well, such as straw's value as a resource for animal bedding and roughage and its price on the market. It is not always cost effective to plough in straw, especially when the stubble and plant roots are re-ploughed anyway. The retention of over-winter stubbles can attract a payment under the voluntary agri-environment schemes in place in all parts of the UK[37].

The Welfare of Farmed Animals (England) regulations 2007 make clear that comfortable, adequately drained, dry bedding must be available at all times. However, this does not have to be straw. Fine woodchip and sawdust are acceptable alternatives. The Defra cattle code guidelines[38] suggest appropriate uses of straw, not only as bedding (straw yards for dairy herds where appropriate, and the changing of straw daily) but also as roughage in the animals' diet[39]. This reflects the traditional use of straw for these purposes.

Box 4. Woodfuel supply chain management at Estover Energy[40]

Estover Energy is a start-up company planning to support and promote the use of locally, sustainably sourced, wood fuels for combustion in 5MWe CHP plants. The company will submit its first planning applications in the coming months, and hopes to install three to five CHP plants in the near future around southern and northern England and Scotland. Estover Energy strives to source all wood inputs from within a forty mile radius around its plants and all source woodlands are to be certified. This limits transport emissions and can yield local ecologic and economic benefits. Estover Energy organises local woodland owners into consortia to supply its CHP plants. The plants are located close to local businesses and industries that are key end-users of the heat generated, for example greenhouses, sawmills, dairies and distilleries (electricity produced is fed into the grid). A major aim is to revitalise woodland management by providing a profitable market for woodchips, the lowest grade of output. Key supply and organisational challenges are:

- to organise and manage consortia of woodland owners, technology providers and energy buyers;
- to renew interest in woodland management and convince woodland owners of the consortium-based approach;

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[37] See eg: http://naturalengland.etraderstores.com/NaturalEnglandShop/NE226.

[38] http://www.defra.gov.uk/foodfarm/farmanimal/welfare/onfarm/documents/cattcode.pdf

[39] Recommendation no. 52: 'Sufficient roughage must be available in all diets to reduce the risk of inducing bloat or laminitis. In intensive barley beef systems, long roughage, such as straw, should be made available *ad lib*. Where total mixed rations are used, you should seek specialist advice.'

[40] http://www.estoverenergy.co.uk/

- to attract sufficient finances mostly from private equity and banks to provide the technology and equipment (setting up a 5MWe plant costs about £20m with an approximate payback time of 9-11 years); and
- to secure sufficient wood supply over time so as to make investment in equipment viable by committing wood suppliers to long-term supply contracts.

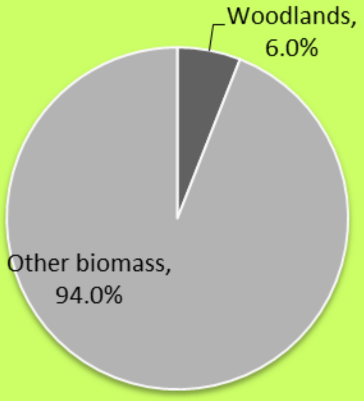
Estover Energy hence acts as a mediator in the whole supply chain from the fuel producers to the end users of the energy. This approach aims to safeguard the viable operation of CHP plants that will use around 60,000 tonnes of woodchip per year (for 5 MW plants). For the life of a CHP plant, this translates into a catchment area of around 15,000 to 25,000 acres of forestry, with harvesting each year not surpassing the sustainable yield. Estover Energy estimates that if 100 plants of this type were built yielding 500MWe (this is a realistic goal in terms of wood availability) they could meet 7 per cent of the UK's renewable heat target. Attracting sufficient capital is a major current challenge, dependent largely on stable government support.

4.4 Biomass harvested from new and existing woodlands

Biomass harvested from new and existing woodlands – 2020 estimate

	PJ	Mtoe
Woodlands	29	0.70

Stemwood	6.0%
Short Rotation Forestry	0%



Source: Based on estimates of potential from Howes *et al* (2011).

The UK is one of the least densely forested countries in Europe, with a total forest cover of 2.8 million ha, around 12 per cent of the total area. Over one half (53 per cent) of the total woodland area in Great Britain is made up of conifers although this proportion ranges from 31 per cent in England to 72 per cent in Scotland. Until 1980, woodland expansion consisted primarily of the commercial planting of conifers, but now 80 per cent of new planting is broadleaves, in response to incentives for planting native trees and creating new woodland on former agricultural land. Alongside plantations many UK forests and woodlands are multi-functional, widely used for recreation and managed as an important resource for biodiversity. There are around 500,000 ha of ancient semi-natural woodland, 150,000 ha designated as Natura 2000 areas and a total of 600,000 ha (21 per cent of the total) with some form of landscape or nature protection.

Although in principle 2.4 million ha of forest is available for wood supply, only half the annual increment is currently harvested. In 2008, a total of 8.2 million green tonnes of domestically grown softwood was delivered to UK industries, mainly sawmills, as well as 0.4 million green tonnes of UK grown hardwood. An estimated 1 million oven dry tonnes of woodfuel were also supplied, mostly as wood chips but also logs and wood pellets. The UK imports around 85 per cent of its processed wood and wood products, to the value of £5.8 billion in 2009, including sawn wood, panels, pulp and paper. The main wood product export from the UK is paper. The quality of woodfuel and pellets made from timber is often superior to that from other forestry operations such as short rotation coppice (SRC) or of arboricultural arisings and wood waste and they burn efficiently. However, any harvesting from forests needs to be done in a sustainable way in order to prevent negative biodiversity impacts (see section 3.2).

Biomass can be harvested from existing and in the future from newly planted woodlands (conifer or broadleaved). The main resource will be existing woodland since expansion is occurring only slowly at the moment. In principle, increasing the woodland area could provide benefits in terms of enlarging the available biomass resource for both material and energy use, providing recreational space and benefiting woodland biodiversity. The impact on biodiversity is mainly determined by the characteristics of the former land use, so careful spatial planning is needed.

As discussed in Section 3.2, the lack of management in many of the UK's woodlands is a result of the competitive advantage of producers elsewhere, and also a lack of responsiveness on the part of the sector to new potential domestic markets. The primary processing sector has been slow to diversify away from production of softwood timber for saw logs and pulp, into new markets. The English Forestry Commission's *Woodfuel Strategy for England* (2007), aims to bring an additional 2 million tonnes of woodfuel to market annually by 2020 – equivalent to 4 TWh (or around 2 per cent of the renewable energy needed to meet the UK's 2020 target) – by improving woodland management and through new planting. The 2011 – 2014 Woodfuel Implementation Plan (Forestry Commission England, 2011) is designed to operationalise this target. Wales has a target of at least 100,000 hectares of new woodland planted over the next 20 years, and the newly introduced 'Glastir' woodland planting grant includes a category of 'carbon woodland'. This would represent a major acceleration in the current rate of woodland establishment.

The creation of new multi-functional woodlands that are used in part for energy from biomass could provide significant biodiversity benefits if dominated by native species and appropriately managed and located, eg on farmland of both low ecological and agricultural value. The strategic location of new forest areas could also help to buffer sensitive sites, eg from disturbance or pollution, and increase ecological connectivity in fragmented woodland landscapes, for example by the creation of corridors and stepping stones that link up otherwise isolated forest patches. Such actions could help to implement some of the recommendations of the *Making Space for Nature* review (Lawton *et al*, 2010), which aim to increase the coherence of the network of wildlife sites in England and overall ecosystem resilience to climate change.

At the same time it must be recognised that establishing new woodland has a direct impact on other land uses. Less land will be available for food production, with potential consequences elsewhere in the global supply chain – another example of the ILUC problematique.

Box 5. Woodland management at Zetland Estate[41]

The Zetland Estate at Aske (Richmondshire) is a working estate and provides office accommodation for 30 businesses across five sites. Around one third of the estate is ancient or semi-natural woodland. The estate previously used 160,000 tonnes of oil annually to heat its various buildings but, following feasibility assessments, has switched to using biomass for heating. Two boiler houses (one 150Kw and the other 220Kw) are fed with woodchip, predominantly from mixed conifer species, with most based on co-product or the use of arisings from woodland management (the majority of usable roundwood goes to the sawmill market). Cut timber is stored 'in the round' for up to 18 months before on-site chipping direct into a purpose-built chip store. Around 15-16 tonnes of chip is used per week, with the store holding around 5 weeks' supply (75-80 tonnes). The scheme has enabled the return to a traditional programme of forestry, with felling, new planting and growing mature trees as well as significant reductions in the cost of heating and emitted CO_2. The estimated annual emission reductions are 549 tonnes of CO_2.

4.4.1 Potential

In terms of wood resources, the annual wood supplies available from existing UK forests are expected to increase from about 10 million cubic metres of standing volume in 1999 to about 15 million cubic metres by 2015[42]. Stemwood could grow to make up 6 per cent of the UK's bioenergy potential in 2020 as suggested in Figure 4. However, Figure 5 shows that bioenergy from 'forestry products' is rather sensitive to the price level assumed; the resource at £10/GJ being estimated as roughly four times that available at £4/GJ. Short Rotation Forestry (SRF)[43] is a potential middle ground between commercial long rotation forestry and Short Rotation Coppice (SRC). SRF differs from SRC in that it takes longer to reach maturity but has a distinct advantage over SRC in that all harvesting operations can be carried out using conventional methods and equipment and as such no capital intensive investment in complex harvesting equipment is necessary. At the end of the first rotation the cut stumps can be allowed to regrow. At the end of the next growing season, the multiple shoots can be singled out, on the stools, to leave the strongest to grow on

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[41] Factsheet 'Zetland Estate: Carbon Lean Offices in Rural Richmondshire', Forestry Commission England, http://www.forestry.gov.uk/pdf/eng-yh-zetland-case-study.pdf/$FILE/eng-yh-zetland-case-study.pdf.

[42] http://www.forestry.gov.uk/pdf/fcfc001.pdf/$FILE/fcfc001.pdf

[43] SRF is the practice of cultivating fast-growing trees that reach their economically optimum size between eight and 20 years old. When felled, SRF trees are replaced by new planting or, more usually, allowed to regenerate from the stumps as coppice.

for the next rotation[44]. Howes *et al* (2011) believe that SRF will only become available in 2030 under the high price level scenario (see Figure 5).

4.4.2 Current policy

The focus of public support for woodland management generally is on multi-functional forests, intended to deliver economic, environmental and social benefits. In England it is a period of flux following the abandonment of the sales plans in February and the establishment of an Independent Panel on Forestry in March 2011 to consider next steps.

For those forests that have the potential to be harvested for wood fuel there is a range of policies, standards, and certification schemes related to sustainability. The Government's view on sustainable forest management is represented in the UK Forestry Standard (UKFS) (Forestry Commission, 2004) which identifies, through a descriptive process, the forestry practices which are appropriate (or inappropriate) in particular situations. The UK Woodland Assurance Standard (UKWAS), an independent certification standard for verifying sustainable woodland management both incorporates and extends the UKFS requirements[45]. Set up in 1999 (and revised in 2006[46] and 2008[47]) it acts as a single UK based conduit for the international forest certification programme, with approximately 1.29 million hectares of woodland certified[48]. Compliance with the UKWAS is a precursor for entry into two other certification schemes, the Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC). Both schemes allow producers to supply their wood at a premium reflecting the additional environmental considerations undertaken during its production. The compliance with standards and related certification creates challenges for smaller woodland owners, however, in terms of its costs. Providing for group certification schemes could be a way to enable certification and hence greater market access to small-scale owners.

From a woodfuel supply perspective, any investment in new planting would be most useful if geographically targeted to areas of particular demand so as to establish viable supply thresholds, thereby adding flexibility to the system (Forestry Commission England, 2007). The Forestry Commission's Woodfuel Strategy for England outlines the potential co-benefits from tree planting for the purposes of energy production, including increased carbon sequestration, biodiversity, recreational, and flood mitigation potentials but also makes clear that in order to

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[44] Forest enterprise technical note number 17/96 http://www.biomassenergycentre.org.uk/pls/portal/docs/PAGE/BEC_TECHNICAL/SOURCES%20OF%20BIOMASS/ENERGY%20CROPS/SHORT%20ROTATION%20ENERGY%20CROPS/SHORT%20ROTATION%20FORESTRY/ESTABLISHMENT%20AND%20MAINTENANCE%20OF%20A%20WOODFUEL%20RESOURCE%20TDB_TN1796.PDF

[45] http://www.ukwas.org.uk/

[46] http://www.forestry.gov.uk/pdf/ukwasguide.pdf/$FILE/ukwasguide.pdf

[47] http://www.ukwas.org.uk/assets/documents/UKWAS%20leaflet%20-%20Are%20you%20SLIM.pdf

[48] Among other requirements the WAS requires that manager produce long term plans to ensure maintenance of important species and habitats and that the impacts of woodland/ forest plan are considered at the 'landscape level taking due account of the interaction with adjoining land and other nearby habitats'.

provide these benefits woodland creation needs to be introduced alongside good management of existing woodland (Forestry Commission England, 2007). The Scottish Government's Rationale for Woodland Expansion points out that all woodland types are capable of producing fuel wood, but notes that in the future we might see the emergence of woodlands where fuel wood production is the principal objective (Forestry Commission, 2009).

The four devolved governments in the UK administer a range of schemes under which forest and woodland establishment and management are supported, funded through the 2007-13 Rural Development Programmes (RDPs)[49]. These grants potentially can improve the UK woodfuel resource, and are an attractive funding mechanism as they are partly co-financed by the EU. Schemes to subsidise afforestation within RDPs have been adopted in England, Wales, Scotland and Northern Ireland[50]. Although this woodland creation is not generally targeted at biomass production for energy use (except where there is support specifically for Short Rotation Forestry, as in Scotland) nonetheless it has the potential to drive land use change, with significant targets for woodland expansion. The outcome in practice will depend greatly on the level of incentives and the market outlook both for agricultural and woodland products; currently the uptake is not very high. Other RDP assistance schemes such as measure 123 (adding value to forestry products) also can be used to support investment in bioenergy production in the UK if the responsible government departments choose to allocate sufficient resources[51].

Targeting enhanced woodfuel supply in particular, the Forestry Commission has launched the Woodfuel Implementation Plan 2011 – 2014 in June 2011 (Forestry Commission England, 2011). The plan seeks to deliver the goal of providing two million tonnes of woodfuel by 2020 by putting forth the following actions:

- Setting standards for competitive and sustainable woodfuel supply chain;
- Capacity building by developing markets and removing barriers to woodland management;
- Providing access to expert information to contribute to market development in close cooperation with the Biomass Energy Centre (BEC).

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[49] For example: in England, the Woodland Grant Scheme http://www.forestry.gov.uk/forestry/infd-6dfk2u; in Scotland, Rural Priorities Options 8, 45, 46 and 47 http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Options; in Wales, the new Glastir woodland creation grant http://www.forestry.gov.uk/forestry/infd-6j2gxd ; and several woodland grants in Northern Ireland http://www.dardni.gov.uk/forestservice/index/publications/forestry-grant-information.htm

[50] Measures 221, concerned with afforestation of agricultural land, and 223, non-agricultural land, have also been adopted in 66 and 41 (respectively) of the 88 rural development programmes in the EU.

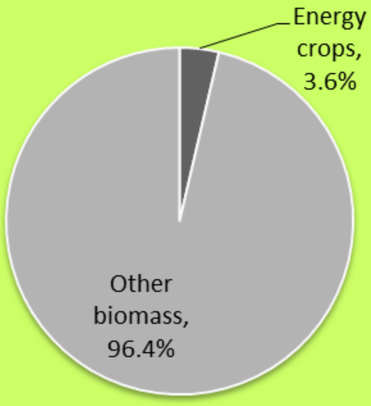
[51] Eight RDPs detail such requirements, two with specific mention of biomass from forest origins.

4.5 Dedicated energy crops

Dedicated energy crops – 2020 estimate

	PJ	Mtoe
Energy crops	18	0.43

- Includes Short Rotation Coppice (eg willow or poplar) and energy grasses (eg Miscanthus)
- Estimated based on land availability scenarios and assumptions about yields, yield increases and planting rates



Source: Based on estimates of potential from Howes *et al* (2011).

This category is normally considered to include perennial energy crops such as tall rapidly growing grasses (eg *Miscanthus,* Canary Grass and Switch Grass) and Short Rotation Coppice (SRC, willow or poplar). Longer growing short rotation forestry (SRF)[52] might also be considered to be an energy crop, but the environmental and policy issues associated with SRF are closer to those of forests and it is therefore treated above in Section 3.4. Biomass derived from all these sources can be used in heat and electricity generation and other applications.

The main environmental issues related to energy crops concern competition for land and related resources such as water. Energy crops in general share the same land requirements as conventional crops and thus compete directly for what is already a limited area of agricultural land and so with food crops. There is also the potential conversion of permanent pasture and semi-natural land for crop cultivation, with consequences for net GHG emissions, biodiversity and landscapes. As discussed with respect to new woodlands, environmental impacts will depend considerably on the location of planting and the habitat that is replaced (see Table 1). Of particular concern is the possibility that energy crops will tend to be placed on less productive farmland, and may therefore result in losses of semi-natural habitats (many of which are UK BAP Priority Habitats[53]) such as wet grasslands, calcareous grasslands and heathlands. In most circumstances the conversion of permanent pasture for energy crop cultivation is likely to result in negative impacts on biodiversity, soil carbon stores, and cultural landscapes[54].

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[52] Ash, alder, hazel, silver birch, sycamore, sweet chestnut, or lime harvested on longer rotations than SRC; a plantation could be viable for 30 years before re-planting becomes necessary.

[53] UK Biodiversity Action Plan www.ukbap.org.

[54] Ploughing up a significant area of permanent grassland in the UK requires an Environmental Impact Assessment.

Table 1. A summary of biodiversity related risks and benefits of dedicated energy cropping[55]

Potential risks	Potential benefits
Short rotation coppice	
○ Reduced biodiversity if semi- natural habitats are replaced ○ Loss of potentially biodiversity rich habitats such as semi-natural marginal farmland when grown on former set-aside land ○ While overall positive impact on bird biodiversity, some important species could be significantly negatively affected (eg open-field species) by large-scale production	○ Longer-lived than annual crops, undisturbed for longer, weedy crop sites ○ Could provide linking corridors between habitats ○ Generally beneficial for biodiversity when replacing intensive arable crop farming ○ Potential increases in the abundance of some birds and butterflies
Miscanthus	
○ Reduced biodiversity if semi- natural habitats are replaced ○ Losses of some rare species if grown on some post-industrial sites ○ Little experience and hence impacts are uncertain ○ Open-field species could be negatively affected, especially by large-scale planting	○ Potential increases in the abundance of some birds and butterflies ○ Less disturbance, more weed and structural diversity ○ Potential benefits if grown on contaminated land that does not hold rare species

Little research has been carried out on the impact of producing energy crops on wild species in the UK, but findings to date on relatively small areas suggest that some energy crops and, especially short-rotation coppice, could support a larger number of species than intensive arable crops (including temporary grasslands). An overview of results is presented in Table 1. However the potential benefit of replacing arable crops even with these more advanced bioenergy crops could be reduced, or even reversed, if in practice large blocks of monoculture bioenergy crops, which might be necessary to supply large plants, reduce habitat diversity and put further pressure on populations of farmland species of conservation concern. Furthermore, a significant expansion of energy crop cultivation on existing cropland would place pressure on food and feed production, causing displacement of farming activities and indirect land use change, threatening permanent grasslands and more natural habitats.

The impact of increased cropping on the quality of groundwater and water courses also needs to be considered. There is the potential that bioenergy crop production replaces other crops that are less water intensive so that the volume of water reaching aquifers and rivers decreases. Evidence is scarce, however. RELU work has shown that SRC willow and cereal crops show similar levels of water use and that these are above those associated with permanent grassland and below those associated with mature woodlands (RELU, 2009). Water use levels for *Miscanthus* are similar to those of woodlands.

Maize is the crop of greatest environmental concern; it has been planted on a large scale for bioenergy production in several countries, particularly for bioethanol, outside the scope of this report, and for biogas production. Maize cultivation can

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[55] Information summarised in this table compiled from: RELU (2009); Tucker et al. (2008) and Gove et al. (2010).

lead to severe soil erosion. Soil reaching water courses can give rise to increased phosphate levels and cause damage to fish populations by clogging the gravel cover of river beds, hence destroying the spawning grounds for fish. Also, pesticide and fertiliser run-off may cause drinking water pollution. Groundwater protection priorities are hence one of the environmental objections to large-scale maize cultivation for energy purposes[56].

4.5.1 Potential

The potential for energy crops depends very much on the assumptions chosen, but following those in Howes *et al*, which focus on 'short rotation coppice or energy grasses' (Howes *et al*, 2011, p4), production in 2020 may remain limited to 4 per cent of total bioenergy supply. In their forecast, shown in Figure 5, the importance of energy crops grows over time, especially in the maximised energy crop production scenario and with increasing feedstock prices. They base their forecasts on the assumption that land required for food production is unavailable for energy crop cultivation, no matter what price is assumed; further, current grassland is assumed not to be converted to energy crops. Higher food crop yields could, however, potentially release land for bioenergy in the future (p4).

The DECC (2010) methodology distinguishes between three scenarios in relation to energy crop potential: a high scenario, energy crops planted on all available arable land and pasture, which is 'neither possible nor desirable' and therefore merely a 'theoretical scenario', a medium scenario taking in all abandoned arable land and pasture and a low scenario with cultivation only to the extent of applications submitted to the Energy Crop Scheme in 2010. All of these exclude certain areas for public access and for environmental reasons. In practice, they argue that the main cultivation areas for energy crops are likely to be Agricultural Land Classes 3 and 4. This is of medium and lower productivity in agronomic terms and, if it were to be the primary location of new bioenergy crops like SRC, would leave the higher classes for higher value crops[57]. However, considerable areas of grassland and farmland of high environmental or amenity value fall into this category. These studies illustrate the point that the potential for new energy crops, including woodland planted primarily for bioenergy purposes, is relatively small if land of high environmental or food production value is excluded.

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[56] In this context, Rob Cunningham (water expert at RSPB, pers. comm.) has pointed at the potential danger of non-renewal of agri-environment schemes and their subsequent use for energy cropping by referring to developments in Germany. According to personal communication with Christina Aue (Oldenburgisch-Ostfriesischer Wasserverband, January 2011), in North-Western parts of Lower Saxony renewable resources legislation provided an incentive to convert former grasslands and other areas left fallow by farmers as part of schemes protecting drinking water quality into maize cultivation for biogas generation with adverse effects for groundwater quality as a result of increasing nitrogen levels. This expansion of maize cropping also crowded out other arable crops (such as wheat and sugar beets). See also http://www.watergov.org/documents/New%20challenges%20Lower%20Saxony.pdf.

[57] On a range of environmental issues the DECC methodology refers to the respective responsible agencies for guidance on whether to exclude them or not. This includes water stressed areas, biodiversity impacts and protected landscapes (DECC, 2010, p15).

4.5.2 Current Policy

There is some incentive to provide energy crops amongst other forms of biomass for electricity production because of the Renewables Obligation (RO). More direct incentives are focussed on forestry in the different countries within the UK, with England the only country to subsidise the establishment of energy crops, through the Energy Crop Scheme (ECS) funded as part of the current England RDP. In Wales recent changes to the RDP (2010) have seen the introduction of Glastir, a new sustainable land management scheme, which gives no indication of future support for energy crops. One likely reason is the abundance of neglected woodland that needs improved management. The previous woodland grant scheme, Better Woodlands for Wales, which helped owners to bring neglected woodlands back into management, (thus providing woody biomass as an output) is now closed to new applicants. From 2013, all woodland grants in Wales will be fully integrated into Glastir, but at present the only scheme open to new applicants is the recently launched Glastir woodland creation grant. Prior to the CAP Health Check in 2008, the RDP for Wales indicated that some 9,000 hectares in Wales could be viable for biomass production during the period covered by the RDP and recent research into Short Rotation Forestry – tree crops grown over a period of eight to 20 years – had indicated that this could be an alternative to energy crops.

Scotland's Rural Development Programme suggests that wood fuel output from Scotland's forests is the primary feedstock in Scotland. There is also a potentially significant resource that could be available from secondary processing industries (recycled wood) but estimates of the amount that would be available for biomass energy use need to be refined. Short rotation coppice is believed to hold the most potential of the other purpose-grown energy crops, but limited commercial experience in Scotland means that it is difficult to predict yields with accuracy and doubts remain about the its economic viability. The area under energy and biomass crops in Scotland is currently around 9,600 hectares (Scottish RDP).

Take up of support under the ECS has been low, as confirmed by research undertaken as part of the TSEC-Biosys project[58]. Sherrington *et al* (2008) have identified poor financial returns and more rewarding alternative activities, notably growing wheat and oilseed rape, in some cases for the biofuel market, as the key barriers for energy crop uptake. Natural England, managing the English Energy Crop Scheme has identified the lack of mandatory sustainability standards for solid biomass as a concern and hence a barrier for investors[59]. It is clear that many farmers are resistant to planting woody perennial crops like SRC as this locks them into a less flexible longer term land use than the annual crops with which they are familiar[60].

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[58] http://www.tsec-biosys.ac.uk/index.php?p=1

[59] See NE response to the Renewables Obligation Order 2011 public consultation, http://www.naturalengland.org.uk/Images/1011-017%20Renewables%20Obligation%20Order%202011_tcm6-24136.pdf.

[60] This is true in other EU countries also as a recent survey among policy makers from different Member States has shown, forthcoming on www.biomassfutures.eu.

5 REVISING THE POLICY FRAMEWORK FOR ENVIRONMENTALLY RESPONSIBLE BIOENERGY

In order to unlock the potential for providing environmentally responsible bioenergy in the UK changes to the policy framework in various areas are needed so as to achieve a pattern of supply more firmly rooted in sustainability priorities.

5.1 Waste policy

Waste policy undoubtedly should continue to support implementation of, and movement up, the waste hierarchy. Priority should be given to the prevention of waste, followed by increased levels of re-use, recycling and composting; only when these have been attempted or are not possible should producing energy from waste become a preferred option. Existing policy and legislation seems to support this sufficiently in broad terms.

The priority as emphasised here is the promotion of energy production from 'genuine waste' (essentially residual waste left after options further up the waste hierarchy have been exhausted). Safeguards therefore could usefully be introduced, whether in waste policy (eg in future national waste strategies) or energy policy, to ensure that incentives are not created to motivate energy production from waste when prevention, re-use, recycling or composting are realistically achievable options.

For certain waste streams (eg food waste from households), the sources of waste can be very diffuse. This presents particular challenges in terms of collecting enough waste to make its use for energy production economically viable. More could therefore be done to support separate collection of such wastes, for example pooling of local authority resources or public procurement contracts to collect food waste from a larger number of households[61]. Steps to achieve more collection coverage would help to ensure both the maximum possible quantity and quality of waste collected.

5.2 Agricultural policies

Since CAP income support payments were decoupled from production in 2005 farmers have much greater freedom to change the management and use of their land in response to market and other incentives, provided that they observe cross-compliance standards. The role of agricultural policies in this arena should be to

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[61] According to a survey undertaken in the second half of 2010 by the Independent on Sunday: all 22 Welsh councils offer separate collection of food waste (or food and garden waste); 41 per cent of the 300 English councils that responded collect food separately; and just over a third of Scotland's 32 councils offer food waste collections (including small-scale trials; We bin 10 Wembleys full of food a year – what a waste of energy, 2 January 2011, http://www.independent.co.uk/environment/green-living/we-bin-10-wembleys-full-of-food-a-year-ndash-what-a-waste-of-energy-2173989.html).

complement the main drivers of bioenergy supply that will be located in energy and climate policy and to ensure that agricultural production is sustainable whatever the final destination of its products, by-products and wastes. As discussed in the previous chapter, the role for dedicated bioenergy crops is small at the moment but potentially will grow modestly over time. Second generation crops, such as SRC, are strongly to be preferred over the use of maize and other arable crops but no dedicated subsidies to encourage production are required.

Agricultural policy does have a role in helping to provide the right framework for the development of several significant sources of bioenergy, notably:
- Anaerobic digestion (AD) on farms;
- Greater use of by-products and wastes;
- Trees and woods on farms (which benefit from some protection under cross compliance and benefit from incentives in rural development programmes).

Incentives for utilising these sources will arise mainly from energy policy, for example the new RHI (see Section 6) but agricultural policy can assist in a number of ways. Measures can be taken to encourage or require good agricultural practice, for example through cross-compliance, and to protect key resources, such as permanent grassland and other farmland habitats. Where there is insufficient market incentive, certain forms of investment can be targeted for aid and, funding can be made available for the development of new forms of rural enterprise under the provisions of the rural development 'Pillar' of the CAP. There are separate Rural Development Programmes in England, Northern Ireland, Scotland and Wales.

5.2.1 Residues

There is a range of agricultural by-products and residues that can be used for energy production. These include straw, farmyard manure and slurry, poultry litter, livestock bedding, cereal crop by-products etc. Most have several different uses already, some of which are relevant to good soil management and the broader sustainability of agriculture. In many cases a proportion of overall supply or 'arisings' is required for other legitimate or desirable uses and another fraction could be utilised for bioenergy if the right price applies and practical arrangements can be put into place. The challenge is to be clear about the appropriate level of use and to fine tune the relevant policy levers for that purpose.

Straw is a critical residue. Howes *et al* (2011) have estimated, for example, a considerable potential for straw to be used as a biomass feedstock, as has Bloomberg New Energy Finance (2010) at a European level. The use of straw as a combustion fuel is one option, as is biofuel production. This scope could be exploited more ambitiously over the next decade, but this will probably require more specific policy interventions than are in place now. However, there needs to be greater clarity about the proportion of straw that is surplus to agricultural requirements in environmental as well as market terms. There is a danger of diverting straw from its use in situ as a low cost source of bedding and dietary supplement for livestock, and its use in soil protection where it would otherwise need to be supplemented from other sources. The DECC (2010) methodology for assessing regional energy potential takes into account the traditional use of straw for animal bedding and fodder; these are substantial from the initial estimate of the available resource. Estimates of potential also should take into account the benefits of using straw residues as a means of increasing soil organic matter content, building soil structure and preventing erosion. If straw is to be used in the production of bioenergy on any scale, policies must ensure that the environmental benefits of using this feedstock (reduced GHG emissions) do not undermine the environmental and animal welfare benefits of using straw residues in situ.

One way of taking this forward would be to revise cross-compliance requirements on soil protection, and the accompanying guidance, so as to encourage farmers to chop surplus straw (and other crop residues) and incorporate these in the soil to improve soil structure and organic matter in arable areas where protecting vulnerable soils from erosion is a high environmental priority. Improved mapping and data availability would be needed to support this. One additional option might be to include reporting requirements on the application of best practice regarding in situ straw use in the sustainability criteria for solid biomass, which are due to be introduced under the Renewable Obligation review (see next section).

Policy proposals to incentivise the use of agricultural wastes and 'arisings' from habitat and landscape management and to safeguard the environment as supply expands include:

- Measures to facilitate the formation of co-operatives of small scale suppliers, and support regional biomass logistic centres (see box 9 in the next section);
- Where agri-environment schemes and other landscape or habitat management activity require cutting and removal of biomass, use advisory/information networks to encourage disposal to local biomass processing units with spare capacity.

5.2.2 Anaerobic Digestion (AD)

AD plants can convert a variety of wastes and residues into electricity and gas, leaving a residue of 'digestate' which has nutrient value. Although they are popular in some countries, notably Germany, where relatively high feed-in tariffs for renewable electricity have been the main driver, uptake of the technology in the UK has been slow. There are several reasons for this (see Box 6). The slow uptake of support for AD under the feed-in tariffs (FITs) helped to trigger the Government's recent fast-track review and was also addressed in the June 2011 AD Strategy and Action Plan (DECC and Defra, 2011). The fast track review introduced a new differentiation in tariffs between plants smaller than 250 kW capacity and larger 250-500 kW plants and new entrants in both classes are awarded higher tariffs as of 1 August 2011 (14 and 13p/kWh, respectively). The consultation prior to this decision sought views on factors explaining the limited uptake, other than the FIT levels. Responses included:

- Lack of awareness / information about AD;
- High capital costs and difficulties in attracting loans;
- Planning issues: AD has been seen as unpopular in some rural communities; planning permission and EA permits have been costly and time-consuming to

acquire; other regulatory barriers have been experienced in relation to waste management when using food waste;

- Opposition to energy crops and the associated need for further investigation of the economic viability of AD without energy crop co-feeding;
- Need for higher tariffs for (small) plants running only on animal wastes[62].

The AD Strategy addresses many of these barriers to AD uptake and proposes various measures to disseminate information and tackle technical and market shortcomings. This should lead to faster adoption in the next decade but the policy needs to be kept under review. Furthermore, both the protection of permanent grassland and measures to focus largely on slurry rather than arable crops as a feedstock need to be robust. Experience in Germany shows the dangers of failing to adopt appropriate safeguards (see Box 7).

Box 6. Insights on AD uptake in the UK

RELU (2011) has surveyed 2000 farmers in England on their attitudes towards AD uptake and found that around 40 per cent of respondents see themselves as 'possible adopters' of AD. These tended to have larger farms, were more likely to be owner-occupiers and were younger and better educated than average. Adoption of on-farm anaerobic digestion was seen as a strategy both to improve farm profit and to reduce pollution and contamination of land and water. As well as using slurry from their beef, dairy and pig production systems, the 'possible adopters' said they would grow feedstocks for AD on land currently used for growing food or animal feed (RELU 2011). Farmers face trade-offs when it comes to the feedstock choice. Using only slurry, manure and grass results in comparatively low energy yields. Including food waste increases yields but it also means that the feedstock and digestates are subject to increased regulatory controls, for example Environmental Permits and Waste Carriers Licences. This means that using food waste usually is only viable for larger plants; hence the attraction of using maize as a feedstock. Other factors affecting the profitability of an AD plant are its location in relation to its feedstocks and users of the biogas and digestates and the incentives available, for example from feed-in tariffs (see below). For dairy farmers amongst others, AD can be useful as a means of slurry management. The liquid and solid digestates are easier to handle than slurry, and less likely to provoke complaints about smell; the liquid digestate is a concentrated source of plant nutrients and can easily be stored for later dilution and use as a fertiliser[63].

As energy policies make AD more economically attractive there is a need to ensure that there are sufficient safeguards to prevent perverse outcomes such as the ploughing of permanent grassland and indirect land use change. For example conversion of permanent grassland to maize or other arable crops grown for AD feedstocks, or intensification of grassland habitat management, may have adverse

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[62] 'Feed-in Tariffs Scheme: Summary of Responses to the Fast-Track Consultation and Government Response', 09.06.2011, http://www.decc.gov.uk/assets/decc/Consultations/fits-review/fits-fast-track-government-response---final.pdf.

[63] Personal communication with Andrew Clarke, Head of Policy at the National Farmers Union (NFU), 8.6.2011.

effects on soil carbon, water quality and habitat and species diversity. Agricultural policy has a role in the creation of such safeguards:

- Introduce in the UK a more targeted, farm-level application of the CAP requirement that Member States must limit conversion of permanent grassland to arable use to not more than 10 per cent of permanent grassland[64]; limiting the extent of conversion at the level of individual farms, rather than the region and separately accounting for permanent grassland converted to forestry (at present this is not included in this grassland conversion data), would reduce the pressure on existing grasslands;
- Continuation of the use of Environmental Impact Assessment (Agriculture) (England) (No. 2) Regulations 2006 (both directly and as part of GAEC cross-compliance) to protect uncultivated or semi-natural areas of more than two hectares in size from agricultural intensification.

Box 7. The German biogas experience

The incentive structure under German renewable energy legislation has led to a massive expansion of the area cultivated with energy crops, up to 1.8 million ha in 2010 (15 per cent of all arable land), out of which 650,000 ha are for energy crops for biogas[65]. The Renewable Resources Bonus ('NaWaRo-Bonus') under the German Renewable Energy Sources Act ('EEG') has facilitated this development. The 2008/2009 reform of the EEG introduced a manure bonus with the aim of reducing the reliance on energy crops. Delzeit *et al* (2011) have analysed the design of both the EEG 2008 and the former EEG 2004 and conclude that the amount of land needed per unit of electricity output has actually increased under the 2008 version of the law. Criticism that biogas expansion has been at the expense of permanent grassland destruction has intensified over the last years. The German Biomass Research Centre (DBFZ, 2010) provides an overview of the shares of permanent grassland conversion to arable land in the different regions (Länder). Several regions have exceeded the 5 per cent threshold for arable conversion which is stipulated as part of cross compliance in the CAP and, as a consequence, the conversion of permanent grassland has been prohibited in these regions. However, according to the NABU (German Birdlife partner) the conversion of grassland in Lower Saxony has not entirely stopped[66].

This is a controversial topic in Germany. Although there is no doubt that a substantial loss of grassland has occurred, some organisations, like DBFZ (2010) challenge the extent to which the conversion of grassland to maize is attributable to increased biogas plants. For example, they claim that no correlation could be found between permanent grassland loss and installed biogas capacity in Lower Saxony, whereas a correlation has been found between the increase in the milk quota and loss of grassland. The evidence for this seems rather anecdotal however. In June

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[64] As required by Article 6.2 of Council Regulation (EC) No 73/2009, and Article 3.2 of Council Regulation (EC) No 796/2004 as amended.

[65] http://www.bio-energie.de/daten-und-fakten/anbau/ and www.destatis.de.

[66] See NABU (German Bidlife) http://niedersachsen.nabu.de/themen/landwirtschaft/gruenland/12386.html. Also see footnote 55 on accounts from Lower Saxony.

2011, the German parliament discusses the government's proposal for the 2012 reform of the EEG; this envisages a revised incentive structure for renewable energy.

Grassland conversion in Germany for maize production (not necessarily clearly related to biogas). The photo shows maize cultivation on a Natura 2000 site with continental steppic grassland in the biosphere reserve Schorfheide-Chorin (Brandenburg). Photo by: NABU.

5.3 Forestry policy

The focus of UK forest policy is on promoting multi-functional management of existing woodland (especially small woodlands that are currently undermanaged), as well as an enhanced woodland creation programme in an attempt to reverse the decline in planting rates since the 1980s which has contributed to the serious projected decline in the carbon sink value of UK forests[67]. In the case of new planting, issues may arise with respect to which of the multi-purpose objectives should be given priority. Even within the objective of reducing net GHG emissions the optimum choice of species depends partly on the timescale. In the short-term SRC willow provides the greatest GHG savings but over 100 years native broadleaf woodland and conifer forests become competitive with SRC and SRF (on many sites Eucalyptus SRF will have the highest carbon benefits , however these are accompanied by considerable biodiversity and hydrological drawbacks).

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[67] From a maximum of 16 $MtCO_2$ per year in 2004, the strength of the 'forest carbon sink' is projected to fall to 4.6 $MtCO_2$ per year by 2020, largely because of the age structure of UK forests and the maturation and harvesting of the woodlands created as a result of the afforestation programmes of the 1950s to 1980s.

Domestic forestry policy is in some flux in England because of recent changes in government thinking about privatisation. There is an opportunity to adopt fresh ideas relating to bioenergy, some of which could be applicable throughout the UK. Most of the incentives for woodland creation and management are embodied in rural development programmes which are co-financed by Pillar 2 of the CAP. There is no certainty that current levels of funding will continue post-2013 in light of CAP and EU Budget reform and a new cycle of RDPs. Some woodland funding streams have already been restricted – for example, in Wales grants for woodland management were closed in 2010 and will reopen for 2013, with a more targeted approach to delivering environmental benefits from farm woodlands, but with at present no guarantee of future funding.

The creation of appropriate new woodland at a faster pace than at present could contribute to a more strategic approach to domestic bioenergy supply. Relevant measures for the next generation of incentive schemes would be:

- differentiated and sensitively targeted tree planting incentives for native species delivered via the four UK Rural Development Programmes; new woodland can generate a variety of benefits if well sited, including buffering more valuable habitats (eg from disturbance or pollution) and, reducing habitat fragmentation (Peterken *et al*, 1995), helping to increase the size and ecological coherence of the current network of habitats and increase their resilience to climate change and other pressures (Lawton *et al*, 2010). Such planting needs to be strategically planned by the delivery agencies and payment rates set to favour group applications from adjoining landowners to create woodland in strategic locations such as adjacent to existing native woodland, linking existing blocks of woodland habitat, along watercourses to reduce diffuse pollution, at appropriate places in catchments to improve infiltration and reduce run-off in heavy rainfall.
- the use of GIS based policy tools to prioritise locations, and target publicly funded support for planting; such tools could build on the new National Forest Inventory map, soon to be published and regularly updated[68], catchment management plans and soil maps;
- considering the need to revise the 1999 EIA Forestry Regulations in terms of the area threshold for new planting schemes (currently 0-5 hectares depending on the conservation designation) and the definition of 'sensitive areas' (which currently does not include peat soils outside designated areas). Such tools could also be used to identify areas where new planting would not be appropriate (e.g. peat soils);
- including new woodland in location sensitive habitat restoration initiatives, following the recommendations in the Lawton report and parallel measures in other parts of the UK.

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[68] http://www.forestry.gov.uk/website/forestry.nsf/byunique/infd-87mcmb.

Policy proposals to encourage owners to bring undermanaged woodlands back into multi-functional management include:

- continued provision (and re-instatement in Wales) of easily accessible financial incentives to manage these woodlands, together with information, advice and training and support for marketing and Research and Development (eg innovative uses for small diameter timber[69]);
- keeping the requirement for sustainable management in the UK Forestry Standard for publicly owned woodland and private woodland supported by public funds;
- incentivising the conversion from clear-fell woodland management to continuous cover management, as proposed in the Welsh Assembly Government's woodland policy;
- encouraging and supporting UKWAS, in the current review[70] of this internationally recognised assurance standard for UK woodland and woodland products and make it easier and cheaper for owners of 'Small and Low Intensity Managed (SLIM) Woodlands' to achieve certification;
- setting up national coverage information networks to link providers and users of woodfuel at the local scale (see box 8 below on Biomass Trade Centres and, for example http://www.woodfueleast.org.uk/).

Apart from bringing undermanaged woodlands into management, these incentives should also address the removal of conifers from planted ancient woodland sites (PAWS) and from other semi-natural habitats .The Forestry Commissions recent Woodfuel Implementation Plan (Forestry Commission England, 2011) delivers some of these needs in focussing on supply chain and market development and providing the right information to woodland owners and this is to be welcomed.

Box 8. Biomass Logistic and Trade Centres to secure local wood fuel supply

The EU funded 'Biomass Trade Centres' project has produced guidelines on setting up regional Biomass Logistic and Trade Centres[71]. A Biomass Logistic and Trade Centre (BLTC) is a regional supply centre providing wood fuels, run by farmers and/or forest entrepreneurs. The central aim of the centres is to secure a high-quality, local source of wood fuel all year round to the heating systems of both private households and businesses and to construct a collective rural marketing channel for biomass fuels and energy services. The product range includes fuel wood, forest wood chips, other biomass fuels, and energy services. Services provided include fuel delivery, involvement in wood energy contracting projects, and expert advice on all issues relating to the proper use of wood fuels. A consistent quality standard of supply in relation to fuel quality and the provisioning of services is guaranteed to the customers of a BLTC.

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[69] For examples see http://www.coedcymru.org.uk/products.htm.

[70] The 3rd edition of the UKWAS is due to be available for use in November 2011 http://www.ukwas.org.uk/standard/revision/index.html.

[71] The project website is: http://www.biomasstradecentres.eu. For the guidelines, see http://nuke.biomasstradecentres.eu/Portals/0/D5.4_BLTC_Guidelines_3steps_EN.pdf

There are already a number of BLTCs based in different regions around Austria (Styria), Italy (Veneto, Lombardia, Toscana), Slovenia (Nazarje, Visoko, Trebnje, Oplotnica), and Germany (Bavaria). In Styria, best practice stipulates that every operating group has to be a local farmers' association with at least ten forest owners – so that the entire added value remains in the region. There is a minimum storage quantity in any biomass centre of 500 solid cubic metres of energy wood (the energy equivalent of one million kilowatt hours of primary energy). As a minimum, the range of products must include firewood, wood chips and split logs from regional forests; the import of raw materials is not allowed.

One of the objectives of the project is to provide information for potential investors in other countries on how to set up and develop a business model of BLTCs at regional level.

5.4 Land use planning policy

Bioenergy production entails changes in land use and management and consequently has a rather important land use planning dimension. More elaborate treatment in the changing current planning policy framework would be appropriate.

5.4.1 Background on land use planning

Existing land use planning systems do not impinge on the sourcing of bioenergy to any great extent; for example farmers are able to use their land broadly as they choose. Planning provides some safeguards against inappropriate development but has not been used as a tool to assist the emergence of appropriate land uses for sustainable bioenergy. However, as the scale and impact of bioenergy production increases it will become more important to establish an appropriate planning framework, with a land use dimension.

The current Planning Policy Statement (PPS) 22 on renewable energy (England)[72], whose scope includes ***small scale*** (<50 MW) biomass heating and combined heat and power schemes, calls for:

- local planning authorities and developers to 'consider the opportunity for incorporating renewable energy projects in all new developments' and for local planning authorities to 'specifically encourage such schemes through positively expressed policies in local development documents'; and
- local planning authorities to 'make sure that the effects of the increases [in traffic] are minimised by ensuring that generation plants are located in as close a proximity as possible to the sources of fuel that have been identified' (bearing in mind also considerations such as connections to the grid and the potential to use heat generated from the project).

PPS22 will be abolished once the new National Planning Policy Framework (NPPF)[73] is in place (both relate to England and to <50 MW generation only). The proposed

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[72] Office of the Deputy Prime Minister, Planning Policy Statement 22: Renewable Energy, 2004, http://www.communities.gov.uk/documents/planningandbuilding/pdf/147444.pdf.

NPPF[74] includes provisions on local renewable energy deployment and calls for local authorities to 'consider identifying suitable areas for renewable and low-carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources'. Local authorities in England should further 'design their policies to maximise renewable and low-carbon energy development while ensuring that adverse impacts are addressed satisfactorily'. When assessing planning applications, local authorities in England should 'apply the presumption in favour of sustainable development and not require applicants for energy development to demonstrate the overall need for renewable or low-carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions'.

The revised Overarching National Policy Statement for Energy (EN-1)[75] includes some broad planning considerations related to renewable energy recognising significant increases in renewable energy generation are required and in particular the advantage of biomass and energy from waste to provide 'dispatchable' power, satisfying peak load and base load electricity needs. The revised National Policy Statement for Renewable Energy Infrastructure (EN-3)[76] goes into more detail on planning related to biomass and waste combustion, and covers plants that use waste (possibly including non-renewable sources of waste) and/or biomass as a fuel, and that generate ***more than 50MW*** of electricity. It recognises the various sources of biomass covered by this report (biomass from conventional forestry management, from agricultural crops and residues, biodegradable waste, sewage sludge, animal manure, waste wood from construction, and food waste). It also states that biomass combustion for electricity generation is likely to play an increasingly important role in meeting the UK's renewable energy targets. Again it recognises that the recovery of energy from the combustion of waste 'will play an increasingly important role in meeting the UK's energy needs' and should be 'in accordance with the waste hierarchy'. All of these points are reflections of the renewable energy policy strategies that are in place.

On the issue of sustainability criteria for biomass, EN-3 refers to provisions under the Renewables Obligation, which enhances the need to get these sustainability criteria right in the first place (see section 6.1.1 below on this). EN-3 additionally requires that the Infrastructure Planning Commission (IPC, which will be replaced by the Major Infrastructure Planning Unit within the Planning Inspectorate) consider issues such as increased traffic volumes and changes in air quality when processing applications. It states that consent for renewable energy projects in areas with

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[73] For the draft proposal put forward on 20 May 2011 see: http://www.nppfpractitionersadvisorygroup.org/.

[74] Put forward for consultation on 25th of July 2011: http://www.communities.gov.uk/documents/planningandbuilding/pdf/1951811.pdf.

[75] The National Policy Statements for Energy (for England and Wales) were approved by the House of Commons on 18th of July 2011; EN-1: http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1940-nps-renewable-energy-en3.pdf.

[76] http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1940-nps-renewable-energy-en3.pdf.

nationally recognised designations (Sites of Special Scientific Interest, National Nature Reserves, National Parks, Areas of Outstanding Natural Beauty) should only be granted where the objectives of designation of the area will not be compromised by the development, and where any significant adverse effects are clearly outweighed by the environmental, social and economic benefits. Particular considerations also apply to developments in Green Belts.

The Localism Bill, published by the Coalition Government in December 2010, abolishes regional spatial strategies in England and will further modify the planning system. The Bill introduces new rights for communities to draw up neighbourhood development plans and build small developments, whilst recognising that some planning decisions (eg on environmental issues or transport infrastructure) must involve cooperation between groups of local authorities. Rather than trying to create entirely new structures for the planning aspects of bioenergy production, these new arrangements for planning do seem to offer potential for local communities to decide upon small local bioenergy developments, and for groups of local authorities to decide jointly on larger (eg regional) developments.

5.4.2 Recommendations

The 'presumption in favour of sustainable development' put forward in the draft NPPF for England means that 'plans should be prepared on the basis that objectively assessed development needs should be met, unless the adverse impacts of doing so would significantly and demonstrably outweigh the benefits'. There is fear that this outspoken pro-development stance risks jeopardising the protection of nature protection sites[77]. On the positive side, the proposed NPPF provides a strong policy framework for the development of renewable and low carbon energy. It could be strengthened further by calling local authorities to *identify* instead of to *consider* 'identifying suitable areas for renewable and low-carbon energy sources', as was suggested by the practitioners advisory group. The advisory group further usefully introduced a spatial component calling to 'identify *and map* opportunities for renewable and low carbon energy, based on ecological sensitivity and generation potential'[78]. This type of spatial approach was also put forward in a previous IEEP report on onshore wind planning (Bowyer *et al*, 2009).

Although the planning system does not explicitly provide for it, it would indeed be beneficial to maintain a supra-local authority overview of bioenergy supply to complement local, largely site based procedures. This would help to ensure that bioenergy plants of any size are built in areas where there are relevant resources (eg from forestry, crops or sewage works), and at the scale relevant to the size of that resource, given that the areas from which sources can be accessed do not necessarily coincide with local authority boundaries. This could be done by a small dedicated 'observatory' or similar mechanism within an existing body, such as the

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[77] Commentary by the RSPB on the draft NPPF (25th July 2011): http://www.rspb.org.uk/news/285404-wildlife-threatened-by-short-sighted-planning-reform

[78] Emphasis added; http://www.nppfpractitionersadvisorygroup.org/wp-content/uploads/2011/05/A-proposed-draft-from-the-Practitioners-Advisory-Group.pdf , p43.

Environment Agency (or its counterparts in the other Devolved Administrations) or the Committee on Climate Change. In Scotland, this type of planning approach to bioenergy development could well be coordinated as part of the implementation of Scotland's first Land Use Strategy, published in early 2011[79]. It could be facilitated by a 'bioenergy mapping' process, linking sources of bioenergy to locations where demand exists or is developing, and helping to provide an economic case for the development of environmentally responsible bioenergy. The mapping and resource appraisal process could usefully build upon existing regional potential studies or could be a bottom up process of collating data from mapping exercises commissioned at local level in order to inform oversight activities[80]. Depending of the scale of the bioenergy plant, developments are consented on local authority or Secretary of State level. It is important that the decisions taken at either level are guided by the same criteria and evidence base, something the envisaged observatory could provide. The existing planning systems, including the changes envisaged in the current restructuring, appear to lack capacity to offer a strategic overview or to guide appropriate implementation. Creating an effective oversight mechanism could be introduced most usefully as a part of wider (renewable) energy planning[81].

CHP deployment, important for the efficient utilisation of what will remain a relatively limited bioenergy resource, is an issue with an important planning dimension, especially when new projects rely on district heating networks for heat uptake. Whilst the National Policy Statement (England and Wales) suggests that planning applications should either include CHP or demonstrate that the option has been fully explored, this currently appears to be more of a 'box-ticking' exercise rather than a genuine encouragement to deploy CHP. More decisive measures are now needed. The siting of power plants is key and should be based on where heat loads are. A power to enable local authorities to withhold consent from developers whose proposals do not involve connection to a heat network would help to promote CHP and the development of district heating networks. Increasing size of plants makes it more difficult to fully take up the heat, which provides a further ground for smaller-scale plants, a point also highlighted in the Scottish Draft Electricity Generation Policy Statement[82].

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[79] 'Getting the best from our land: A land use strategy for Scotland', http://www.scotland.gov.uk/Resource/Doc/345946/0115155.pdf.

[80] Regional potential studies have been conducted based on a methodology developed by DECC (2010) for the south west of England (Regen SW, 2010), the north west (NWDA, 2010) and the south east (South East Planning Partnership Board, 2010). See Annex C for a short summary of their results. Another useful source is work under the Biomass Futures project on spatially identifying the EU biomass potential on NUTS 2 level: http://www.biomassfutures.eu/work_packages/WP3%20Supply/D3.3%20Atlas_of_technical_and_economic_biomass_potential_March%202011%20FINAL.pdf.

[81] In the same vein, a report commissioned by the RSPB (Sheate *et al*, 2011) recognises that 'renewable energy resources of the UK are not equally distributed; in fact there is poor correlation between areas of demand and physical supply. A national perspective on resources, supply and demand would facilitate delivery of appropriate infrastructure and demand management measures' (p4).

[82] http://www.scotland.gov.uk/Resource/Doc/331717/0107930.pdf. The point is reiterated in the '2020 Routemap for Renewable Energy in Scotland' from 2011: http://www.scotland.gov.uk/Resource/Doc/917/0118802.pdf.

6 BIOENERGY IN UK RENEWABLE ENERGY POLICY AND THE ENERGY SYSTEM

6.1 UK renewable energy policy and the biomass hierarchy

The previous section focused on the policy priorities on the supply side with the aim of establishing an environmentally responsible bioenergy sector. However, bioenergy demand largely is driven by UK renewable energy policy, which in turn to a large extent stems from the national target set out in the EU Renewable Energy Directive. The National Renewable Energy Action Plan (NREAP), following the UK Renewable Energy Strategy of 2009 (DECC, 2009), outlines which renewable sources will be deployed to scale up renewable energy supply sufficiently to meet the binding RED targets[83].

6.1.1 Sustainability Criteria

In line with its commitment to sustainable bioenergy use, the Government, in its December 2010 response to the Renewable Obligations Order 2011 consultation, stated that it would go ahead with the introduction of binding sustainability criteria for solid biomass and biogas[84]. These will be largely aligned with the Renewable Energy Directive's criteria for biofuels and bioliquids and are to be enforced by April 2013 for generators above 1 MW (Mandatory reporting as a first step is introduced for all generators above 50 kW as of April 2011)[85]. Biomass derived purely from waste is exempted both from reporting on and compliance with sustainability criteria. An approach to sustainable forest management designed to complement the criteria will be developed further in close collaboration with the Forestry Commission[86]. Delivery on these commitments would start to fill an important gap at the domestic level. Indeed, this gap continues to apply at the EU level, where the lack of harmonised binding sustainability criteria for solid and gaseous biomass has been criticised as a loophole both by environmental NGOs and also by various European governments. However, as with the sustainability criteria in the Renewable Energy Directive, UK provisions currently are not comprehensive as they do not contain rules mitigating indirect land use change nor mandatory standards for

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[83] As this report focuses on the heat and electricity sectors, this section will not discuss the Renewable Transport Fuels Obligation (RTFO). It requires fossil fuel suppliers to blend in a certain percentage of renewable fuels in road fuels supplied to the UK market.

[84] With unified implementation in the devolved authorities. Whether or not binding criteria will be introduced for solid and gaseous biomass at the EU level will be announced by the European Commission by the end of 2011. A public consultation has been conducted on the 'preparation of a report on additional sustainability measures at EU level for solid and gaseous biomass used in electricity, heating and cooling' (closed on 29 March 2011), http://ec.europa.eu/energy/renewables/consultations/20110329_biomass_en.htm.

[85] In particular, the sustainability criteria for energy from solid and gaseous biomass include a GHG savings reduction target of 60 per cent of the current EU fossil fuel comparator (meaning a maximum carbon intensity of 285.12 kg CO_2 per MWh. The RED consistent land use criteria imply a restriction of the conversion of highly biodiverse land and of land of high carbon stock value. It is furthermore intended to consider how any proposal on indirect land use change put forward at the EU level could be taken up and applied to solid biomass and biogas.

[86] 'Government Response to the Statutory Consultation on the Renewables Obligation Order 2011', http://www.decc.gov.uk/assets/decc/Consultations/Renewables%20Obligation/1059-gov-response-ro-order-2011-cons.pdf.

water, soil and air protection nor do they include social criteria. A decision on the definition of highly biodiverse grasslands that are to be excluded from biofuel production under the provisions of the RED is still outstanding at the time of writing. These remaining limitations need to be addressed in an appropriate way. While this only affects the binding sustainability criteria for biofuels and bioliquids throughout the EU, it will be of relevance to the UK context as the Government has embraced the land use related criteria contained in the RED's sustainability scheme for adoption in relation to domestic biomass and biogas. The protection of areas of high biodiversity value and high carbon stock value critically hinges upon reliable certification of bioenergy sources against these land use criteria.

6.1.2 The Renewable Heat Initiative

Biomass energy sources for the electricity sector are eligible for support under the UK Renewables Obligation (RO). The feed-in tariffs (FIT) scheme does not initially support solid and liquid biomass technologies. It does, however, support anaerobic digestion[87]. The Renewable Heat Incentive was announced in March 2011[88] and closed the previous imbalance in support for renewable heat relative to incentives for renewable electricity. This is particularly relevant in the context of bioenergy, which is much more efficiently converted in CHP or heat only applications than in pure electricity generation plants. The RHI will apply to England, Scotland and Wales.

Support under the RHI is being introduced in stages. As of July 2011, non-domestic heat installations will be eligible for long-term tariff support. This first phase of the RHI will also see the introduction of Renewable Heat Premium Payments for domestic users installing renewable heat technology. These payments could be specifically targeted at off gas grid housing. Tariff support for domestic appliances will be introduced in the second phase in line alongside the forthcoming Green Deal for Homes initiative which will tackle energy efficiency in the housing sector, which is expected to start around October 2012. Only renewable heat systems that were completed after 15 July 2009 (the date of publication of the Renewable Energy Strategy) will be eligible for support under the RHI. Eligible technologies include biomass boilers, biogas, energy from waste, and the injection of biomethane into the natural gas grid (together with ground and water source heat pumps, solar thermal,

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[87] The lower limit for receiving support under the FIT scheme (in operation since 1 April 2010, only in Great Britain so far) is 5 MW and 2 kW for micro CHP applications. Under this scheme, the six big energy suppliers must make regular payments to householders and communities who generate their own electricity from renewable or low carbon energy sources, including anaerobic digestion (AD). The FIT for AD dependent on plant size (for 1 April 2010 – 31 March 2013) are: plants ≤ 500kW: 11.5 p/kWh; and plants > 500kW: 9 p/kWh, http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/feedin_tariff/feedin_tariff.aspx. From the 1st of August 2011, new entrants into the FIT scheme will receive amended tariffs, for AD, as decided on by the Government in its FIT fast-track review announced on 9 June 2011: plants ≤ 250 kW: 14.0p/kWh; plants >250 kW – ≤ 500 kW: 13.0p/kWh, http://decc.gov.uk/en/content/cms/news/pn11_046/pn11_046.aspx.

[88] Renewable Heat Incentive, March 2011: http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renewableheat/1387-renewable-heat-incentive.pdf.

deep geothermal and renewable CHP)[89]. Unlike the RO, the RHI will not introduce mandatory sustainability criteria for biomass use, but only mandatory reporting for installations above 1 MW. However, the government has suggested that mandatory criteria could be introduced as of 2013 following an anticipated consultation on this issue. Regarding air quality, the Renewables Roadmap (DECC, 2011) has announced that emission performance standards are to be introduced in the second phase of the RHI to regulate NOx and particulate matter emissions from boilers below 20 MWh (small-scale boilers above this threshold are regulated under local authority air pollution control).

Introducing targeted support for renewable heat is a very important step towards increasing the deployment of renewables and moving UK energy supply onto a decarbonising path. It is an important pioneering measure. However, certain aspects of the RHI could have been designed in such a way as to enhance its environmental benefits and hence to align the support for renewable energy with the wider environmental goals promoted in this report. In particular:

- as bioenergy is anticipated to be of particular importance in the heat sector, differentiated support levels in line with the feedstock hierarchy set out in this report would have been a valuable mechanism for achieving multiple environmental objectives, and establishing the right strategic direction for a growing sector, Although some steering is provided, though, by granting small and medium sized heat plants higher tariffs distinguishing between different supply chains is even more important. This is discussed further below;
- it is important that the provisions for protecting permanent grassland from conversion into maize are robust, either through domestic measures or by farm-level restrictions under existing CAP rules (see Section 5.2 above): While the RHI does recognise the danger of food crop displacement by energy crops co-feeding AD biogas plants, there is no formal review mechanism envisaged apart from the Government investigating and discussing the issue. A mandatory review of the pattern of feedstocks supplying AD plants and the associated land use impacts after 2 years of operation of the RHI could provide a meaningful environmental safeguard (see also Box 9).[90] The German experience can be drawn on here;
- establishing appropriate sustainability criteria for smaller plants and their supply chains needs to be considered. Administrative burdens on small-scale heat generators clearly should be kept to the minimum necessary, not only

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[89] Bioliquids are not supported from the outset as more evaluation is needed on the interplay of bioliquids use in different energy and non-energy sectors.

[90] In accordance with the revised German Renewable Energy Sources Act 2009 (Erneuerbare-Energien Gesetz, http://bundesrecht.juris.de/eeg_2009/BJNR207410008.html), biogas plant operators in Germany have to keep 'feedstock diaries' in order to benefit from feed in tariffs (for the template, see eg http://www.suewag-netz.de/property/1298045456/file/Einsatzstofftagebuch.pdf). Apart from the type of feedstock and its quantity the origin of the feedstock (internally or externally sourced, including a guarantee of origin in the case of the latter). This could provide the necessary database for tracking of land use and wider feedstock sourcing effects resulting from enhanced AD promotion.

because of their size but also because they can play an important role in utilising biomass harvested from eg local and low-intensity woodland management. However, sustainability criteria should apply unambiguously to the upper end of the supply chain and most notably the provisioning and sourcing of biomass;

- reviewing the 1 MW plant size threshold in relation to sustainability criteria after one year of operation of the RHI including an assessment of the size structure of newly created plants. An abundance of slightly-below-1-MW plants might have cumulative environmental impacts that would warrant the lowering of the threshold. This holds equally for the 1 MW threshold that will be part of the RO sustainability criteria;
- renewable heat counts as 'zero carbon' under the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme. The RHI states that the Government may review this later. While the zero counting rate is largely unproblematic when it comes to heat from eg solar thermal or heat pumps the case is very different for biomass that is derived from land use activities, including forestry that potentially emit greenhouse gases. There is also the issue of carbon debt, discussed in section 3.1 above. The zero carbon rate is therefore unsatisfactory and needs to be reviewed as soon as possible;
- no extra subsidies for CHP applications are provided under the RHI. This can be seen as a missed opportunity for setting incentives for greater CHP uptake and associated investments in district heating infrastructure, the benefits of which would go beyond renewable heat by fostering the use of excess heat from conventional electricity generation.

6.1.3 The Renewables Obligation

A growing volume of biomass is being used as fuel for electricity supply, much of it imported, partly in response to the requirements of the Renewables Obligation. However, electricity generation from biomass is less efficient than heat conversion and therefore should not be prioritised. Under the Renewables Obligation, electricity suppliers need to present Renewable Obligation Certificates (ROCs) in order to prove that a proportion of their electricity supplies originate from renewable sources. ROCs are issued to electricity generators according to how much they generate from renewables. The benchmark is that one ROC is granted per megawatt hour generated but in order to reflect differences in renewable electricity generation costs, different forms of renewable energy technologies receive different numbers of ROCs per unit of production. Within this framework distinctions are being made between different forms of bioenergy. Annex B provides detailed overviews of both ROCs and feed in tariffs under the current rules.

As with the RHI there is a need to distinguish much more clearly between bioenergy sources, according to their environmental sustainability and the ROCs provide a mechanism for this. ***The banding of the Renewables Obligation could be changed to reflect not only the economic costs but also the environmental impacts of feedstocks according to the hierarchy developed above. Introducing a finer categorisation of biomass sources would be an important step towards ensuring***

that policy driven demand meets long term societal requirements*[91]*. Bioenergy sourced in an environmentally responsible way should receive a 'ROC-environmental bonus'. Such a bonus would be designed to reflect the full environmental costs and benefits of the different biomass energy sources[92]. Currently, anaerobic digestion and dedicated biomass CHP is incentivised by being attributed two ROCs, two being the current maximum attributed. No distinction is made between the type of biomass involved and both energy crops and 'biomass' receive two ROCs. In fact, energy crops are more generously supported under the present scheme as they receive two ROCs no matter whether combusted in CHP plants or not. This is because of the 'energy crop uplift' granted to newer, less developed, supply chains where higher costs can be expected. Waste products such as landfill gas, sewage gas and 'energy from waste with CHP' receive less support, qualifying for 0.25, 0.5 and one ROC, respectively. This is sensible as over-incentivising food and other types of waste that could in practice be avoided is not desirable from an environmental point of view. Incentives might create a situation where renewable energy support prevents the reduction of waste, which should be the overriding environmental objective. However, this argument does not apply to sewage sludge, support for which is unambiguously desirable.

The fact that energy crops and more general biomass receive the same level of support shows why the current design of the Renewable Obligation does not favour the feedstocks that have been determined to be the most environmentally sustainable, as suggested in the hierarchy above. The RO does, however, provide incentives for increased conversion efficiency by favouring anaerobic digestion over co-firing and CHP over non-CHP. This is a helpful foundation on which to build a system of incentives based on the environmental sustainability of different sources of supply.

Box 9. Avoiding perverse environmental pressures from AD plant

A few words of caution on AD development. While the use of waste in AD is unambiguously beneficial, aggressively expanding AD deployment must not incentivise the large-scale cultivation of maize or other arable crops to co-feed AD plants together with animal slurry, as has been witnessed in Germany (see Box 7 above). The government recognises this risk in its RHI Impact Assessment to some degree. Setting up an advance warning system would be a useful way to monitor the impact on agricultural crops and permanent grassland in the vicinity of AD plants and hence to mitigate the risk. AD operators that receive subsidies under the RHI or the

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[91] The banding review of the Renewables Obligation is to be published in autumn 2011 (after a summer 2011 consultation) to come into effect on 1 April 2013 (1 April 2014 for offshore wind).

[92] The principle of external costs of energy sources and full environmental and social cost and benefit accounting is recognised in the Renewable Energy Directive, see recitals (26) and (27), as well as (95) in relation to biofuels. Furthermore, in a memo explaining the Commission's State Aid Guidelines for Environmental Protection (referenced in the RED), it is stated that in order to reach renewable energy targets, the EU's Energy and Climate 'package is introducing market mechanisms, which should secure that polluters pay for their pollution and that more environmentally friendly technologies are supported', http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/31&format=HTML&aged=1&language=EN&guiLanguage=en.

FIT scheme should be required to issue a report on the share of agricultural crops in their feedstock resource base every year.

A complementary tool would be to require planning permission for all new AD plants in order to determine the suitability of biogas plant locations and possibly the promotion of smaller biogas plants. This could be taken forward in coordination with selective support for investment in farm or community-scale AD installations, especially in areas where there are sustainable local supplies, eg of surplus manure/slurry, arboricultural arisings, or undermanaged woodland). While **smaller plant sizes reduce transport costs and emissions, the trade off is that these are also** less efficient in converting biomass to biogas[93].

The UK Government has consulted on whether 'controls are necessary to prevent the wholesale expansion of energy crops for AD' as part of its FIT fast-track review. A majority (57 per cent) of respondents stated that controls are needed. Of those that disagreed some pointed to the advantages of some energy crop co-feeding to make AD viable, with some suggesting that these could be sourced from normal arable crop rotations. Amongst the policy interventions favoured by respondents to fine tune the system were the need to get the FIT rates right, incentivising waste use, and the responsibility of the planning system to prevent major shifts in ag-production to energy crops[94]. There is a danger that the Government's emphasis on decision making by 'local authorities, communities and industry', reiterated in the June 2011 AD Strategy (DECC and Defra, 2011), will lead to insufficient monitoring and hence inability to control such shifts. The strategy does state, however, that the Government will gather evidence on the impact of a range of bioenergy feedstocks as part of the Bioenergy Strategy, expected for publication in late 2011. This opportunity should be taken.

6.2 Bioenergy in the wider energy system

The challenge of creating a sustainable future for bioenergy in the UK extends beyond the immediate questions of designing appropriate incentive measures and sustainability criteria. The relatively limited domestic resources available need to be used as efficiently as possible within a strategic framework that looks several decades ahead as well as addressing the period to 2020.

The considerable scope for utilising bioenergy resources on a larger scale needs to be tempered by an awareness of the constraints on expanding supply and the great uncertainties surrounding the sustainability of imports. A biomass strategy should aim to maximise greenhouse gas emissions savings at reasonable cost, avoid adverse

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[93] In this respect, Delzeit (2011), based on analyses with an optimization model for Germany that takes into account transport distances and emissions, concludes that large-scale plants are not favourable from an environmental point of view while energy efficiency improvement for small-scale plants should be incentivised. Besides supporting technological improvements in AD, Delzeit (2011) sees room for improvements on the management side.

[94] 'Feed-in Tariffs Scheme: Summary of Responses to the Fast-Track Consultation and Government Response', 09.06.2011, http://www.decc.gov.uk/assets/decc/Consultations/fits-review/fits-fast-track-government-response---final.pdf.

competition for biomass between different sectors and minimise the risks of negative environmental impacts. In practice this implies:

- Demand side measures are needed alongside the current emphasis on increasing supply. Furthermore, any expansion in supply should be compatible with both short and long term decarbonisation goals;
- The importance of developing policies to secure the utilisation of the most efficient technologies available. CHP is a particularly clear case, with the potential to increase the greenhouse gas emission savings relative to fossil fuel use very considerably (Environment Agency 2009a/b). In electrical energy terms CHP can offer efficiency levels of 65-75 per cent, which compares with the more typical 20-25 per cent of biomass fuelled power plants (DECC 2009). The Environment Agency (2009a/b) stresses that the deployment of CHP from the outset is crucial for the longer-term viability of biomass plants in contributing to reducing average GHG emissions from electricity production beyond 2020: As of 2030, electricity generation from biomass without carbon capture and storage (CCS) or heat uptake will not reduce the carbon intensity of the electricity grid;
- A hierarchy of energy efficient end-uses for biomass would begin with heat supply, particularly in industrial and commercial applications, followed by CHP, co-firing of biomass with other fuels, dedicated biomass power plants and finally liquid transport fuels (see Gove *et al* 2010, Defra 2007). This needs to operate alongside the environmental hierarchy discussed earlier in the paper;
- Thinking further ahead towards 2050, even the attractiveness of burning biomass in CHP plants generating heat and power might decrease as other uses become more critical. While this may change, at present bioenergy is the most feasible low-carbon (if sourced responsibly) alternative for fuelling long-haul road freight transport, aviation and industrial high grade heating processes, sectors that will nevertheless have to contribute to reducing emissions in order for the UK to achieve a reduction of greenhouse gas emissions of 80 per cent by the year 2050. In this context, the government's 2050 pathway analysis, which examines different options to achieve the 80 per cent emissions cut whilst meeting projected energy demand, recognises 'sustainable bioenergy [as] a vital part of a low carbon energy system'[95]. Some of the pathway analysis scenarios depend on the use of biomass for electricity generation but with the deployment of CCS technology. In effect,

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[95] HM Government, 2050 Pathways Analysis July 2010, http://www.decc.gov.uk/assets/decc/What%20we%20do/A%20low%20carbon%20UK/2050/216-2050-pathways-analysis-report.pdf. The analysis report includes 'six illustrative pathways' that differ to the extent of efforts undertaken in different sectors. As an example, in relation to bioenergy pathway Alpha is characterised by a 'balanced effort across sectors including a concerted effort to produce and import sustainable bioenergy' while pathway Epsilon 'looks at what could happen if supplies of bioenergy were limited'. The online 2050 calculator tool (http://2050-calculator-tool.decc.gov.uk/) allows the user to choose different assumptions and understand the effect this has on the 2050 UK energy mix and the pathway to get there.

electricity generated purely from biomass would be relatively high carbon by 2030 and even CHP biomass plants would be in this category by 2050;

- Hence bioenergy resources need to be deployed strategically for specific periods and applications in a systematic way within a dynamic framework steering a sequence of transformations required to achieve a low carbon energy system over time. Planning ahead and taking into account longer term decarbonisation objectives needs to be a key element of today's bioenergy development strategy in order to avoid 'locking-in a sub-optimal use of limited bioenergy resources' (2050 Pathway Analysis)[96];
- It would be helpful for the UK government and other EU Member States to soon receive clarity from the European Commission about a proposed EU Energy Roadmap 2050 (expected for late 2011) so as to facilitate longer-term (renewable) energy planning at the national level;
- This will be difficult to achieve without a process of planning in which revisions and fine tuning can occur to ensure that specific measures are still appropriate in a changing context.

7 POLICY CONCLUSIONS: DESIGNING POLICIES FOR A SUSTAINABLE BIOENERGY SECTOR

Bioenergy is projected to play an important and larger part in Britain's energy supply in the coming decades. In the right conditions this will help to reduce greenhouse gas emissions, diversify supply, create economic opportunities and contribute to better management of some resources.

However, to achieve this will require a robust and forward looking policy framework sensitive to the multiple challenges involved. Bioenergy is a particularly challenging policy area for several reasons:

- Bioenergy ***sources are diffuse***; the environmental implications of exploiting them can be significant and not always sufficiently well understood. The most immediately competitive options are often not the most sustainable for the longer term;
- Since there are ***environmental sensitivities*** associated with most bioenergy sources, it is therefore easy to aim policy in the wrong direction as illustrated by recent experiences with biofuels. In particular, the greenhouse gas mitigation potential can be reduced or even reversed in the presence of eg land use change and unaccounted emissions from combustion of some forms of forest biomass.

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[96] Referring to the EU level, the European Commission conducted a public consultation on the 'Energy Roadmap 2050' (open from 20 December 2010 to 7 March 2011, http://ec.europa.eu/energy/strategies/consultations/20110307_roadmap_2050_en.htm). The ultimate roadmap is to be issued in the second part of 2011 and will outline how the EU envisages moving towards a low-carbon energy system.

- There is hence a set of ***environmental costs as well as opportunities*** to be addressed, including promoting the efficient use of waste resources while mitigating the overexploitation of natural resources and finite supplies of land;
- Many ***different actors and strands*** are involved in bioenergy development as it touches upon a range of different policy fields. This calls for a synthetic view on the bioenergy sector but this is not yet fully in place;
- The ***tradability of some bioenergy sources*** and the abundance of marketable biomass resources in several countries have resulted in large scale imports into the UK. Problems associated with this are increased competition for international biomass resources in the light of rising oil prices and growing incentives for exploiting forests, bioenergy crops and other resources on a global scale with insufficient information about the provenance and impact of UK and wider EU imports. A precautionary policy should rely primarily on domestic biomass production unless we can be more certain of the (environmental) impacts of imports.

Additional costs will be entailed in moving to sustainable bioenergy supplies, as with other sources of renewable energy. Generally these will be passed on to consumers. This underlines the need for adequate investment in energy efficiency. However, there will be benefits from diversification of supply, with sustainable bioenergy creating new market opportunities for smaller businesses, increasing competition in the energy market. At the same time it is important to avoid the creation of supply chains that are likely to prove unsustainable in the decades to come and hence give rise to avoidable costs such as stemming from obsolete investment.

The suite of policies of relevance for steering the bioenergy sector such as the RHI are evolving at the moment and the opportunity to sharpen them in relation to sustainable supply and application pathways should be seized now. This agenda is not confined to technological development and renewable energy policy but includes also to other fields, such as land use planning where there is a need and an opportunity now to get the bioenergy component right. ***The policy recommendations formulated in this report focus particularly on introducing environmental safeguards and exploiting the potential for environmental benefits, helping to take the bioenergy sector on an environmentally responsible path into the future***.

Fostering environmentally responsible bioenergy in UK renewable energy policy

- Three key measures provide financial and regulatory incentives for renewable energy uptake. The Renewable Heat Incentive now complements the Renewables Obligation and the feed-in-tariff scheme in the electricity sector and the Renewable Transport Fuels Obligation. In order to promote a sustainable bioenergy supply chain all these measures need to be tuned so as to provide ***positive incentives for environmentally preferable feedstocks*** reaping environmental benefits and creating win-wins. While winding down support for high environmental risk feedstocks ***safeguards*** on the appropriate production of feedstocks are also needed.

- The ***sustainability criteria*** introduced by the Government for solid and gaseous biomass largely will be aligned with the Renewable Energy Directive's criteria for biofuels and bioliquids. While these represent a useful first step in setting up sustainable and traceable supply chains in the relevant sectors, the current sustainability criteria contain gaps and largely follow a 'no harm' approach. A more proactive approach is needed: Environmentally preferable feedstocks could be promoted by changing the banding of the Renewables Obligation to ***reflect not only the economic costs but also the environmental impacts of the principal feedstocks*** according to the hierarchy developed here. This would be a 'ROC-environmental bonus'. A similar sustainability banding approach could be adopted under the RHI. This would offset the higher costs involved in several cases, for example those associated with more scattered and intermittent resources from habitat management and arboricultural arisings, the use of which would benefit the environment in several respects. Added support would be compatible with the rules on national measures in[97] the Renewable Energy Directive.
- In order to establish the extent of such costs, and the precise level of support required, more ***detailed cost estimates*** are needed. These could be usefully tackled in work leading up to the UK bioenergy strategy expected towards the end of 2011[98].
- As part of the safeguards, attention needs to be paid to any ***adverse land use changes*** triggered by bioenergy policy. These may occur through the increased planting of dedicated bioenergy crops, for example maize for AD plants. A robust monitoring system needs to be in place so that an early warning can be given to policymakers. As part of this, AD operators should be required to report on the share of agricultural crops in their feedstock resource base.
- Bioenergy applications for electricity generation alone inevitably have an efficiency penalty and by 2030 will not be a low carbon option. This makes it imperative to ***advance CHP deployment*** instead of electricity-only power plants. In certain localities smaller scale bioenergy fuelled district heating schemes could be particularly appropriate. In order to advance CHP uptake and develop district heating networks, enhanced support for CHP as part of the Renewable Heat Incentive, the siting of power plants based on heat loads and granting power to local authorities to withhold consent from developers

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[97] The German Renewable Energy Sources Act (2008/2009 version) contains a *landscape management bonus* ('Landschaftspflegebonus'), to be revised under the 2012 reform. This incentivises the use of biomass material from urban spaces, recreational spaces but also from arable land under agri-environment schemes. There has been severe criticism from both environmental groups as well as the biogas federation (fearing bad publicity), as parts of the activities eligible for support are intensive-style agricultural practices and not actual 'landscape management'. Personal communication with Liselotte Unseld (Deutscher Verband für Landschaftspflege), 9.6.2011, http://www.nabu.de/landwirtschaft/Umfrageergebnisse_LaPf-Bonus.pdf and http://www.biogas.org/edcom/webfvb.nsf/id/DE_Landschaftspflegebonus_im_EEG_2009/$file/10-03-08_Lapfbonuspositionspapier_final.pdf.

[98] ARUP (2011) has estimated technology costs for renewable electricity generation. The study shows that dedicated solid biomass plants have higher operating costs (£/MW per year) as well as levelised costs (£/MWh) than co-firing biomass plants.

whose proposals do not involve connection to a heat network would be helpful.

- We recognise that ***UK renewable energy policy is in a state of transition*** with plans underway for the Electricity Market Reform proposing to integrate the RO into a new Feed-in Tariff with Contract for Difference scheme (to start in 2014). However, the principles put forward in this report of favouring bioenergy pathways that bring wider environmental benefits over others that lack these benefits or even entail outright risks will remain valid in the changing legislative framework.

Planning for regionally balanced bioenergy supplies

- Since bioenergy development has so many environmental implications and spans so many policy fields, the need for coordination and forward planning is particularly great. In addition to planning within DECC and the essential inter-departmental coordination, there is a case for a ***small dedicated 'observatory'*** or similar mechanism for ensuring that current issues are addressed in an integrated way, appropriate monitoring occurs, linkages are made with regional and local processes etc.
- This would be tasked with facilitating ***smart bioenergy development***, keeping the hierarchy relevant and up to date and taking full account of all the associated benefits and risks. Such a unit could be located within the Environment Agency (or its equivalents the Scottish Environmental Protection Agency and the Northern Ireland Environment Agency) or the Climate Change Committee for instance. Its work would inform land use and spatial planning, helping to identify demand for and supply of environmentally responsible bioenergy sources, matching the two. The aim would be to prevent energy supply and infrastructure developments put forward on an ad-hoc and piecemeal basis, from locking the country into unsustainable and sub-optimal energy pathways.
- An integral approach to bioenergy planning is needed above local authority level acknowledging the fact that matching supply and demand of bioenergy sources is likely to involve crossing local authority boundaries. A cornerstone of bioenergy planning would be a ***bioenergy mapping process***, linking sources of bioenergy to locations where demand exists and helping to provide an economic case for the development of environmentally responsible bioenergy. In Scotland, this kind of planning would usefully be coordinated as part of the implementation of the Land Use Strategy.

Supporting sustainable waste, agricultural and forestry products for use in bioenergy

- Any use of waste for ***energy must not compromise the waste hierarchy***, in which energy use is at the bottom of the hierarchy just before landfilling. To achieve this, monitoring will be required to ensure that incentives are not created to motivate energy production from waste when prevention, re-use, recycling or composting are realistically achievable options.

- Waste sources are often diffuse, making improved ***waste collection and separation infrastructure*** a clear priority to make the use of waste for energy production economically viable. One area for policy innovation would be to pool local authority resources or public procurement contracts to collect food and other forms of waste from a larger number of households.
- Policy needs to ensure that bioenergy development does not take place to the detriment of ***permanent grasslands*** by appropriate use of cross-compliance and working for the improved protection of such grasslands under Pillar 1 of the CAP in the current negotiations. The continued use of Environmental Impact Assessments is needed to protect ***uncultivated or semi-natural areas*** of more than two hectares in size from agricultural intensification. In order to reduce cumulative impacts from piecemeal conversions, the present ***threshold should be examined*** and perhaps reduced or other clauses added, if it is found that significant conversions have occurred below this threshold.
- Small-scale, fragmented ownership of sources of bioenergy, in particular of small woodlands, tends to make the transaction and administration costs of using the source prohibitively high and provides a good case for appropriate planning and selective use of incentives. Following a bioenergy mapping process, ***regional biomass trade and logistic centres*** could be introduced to help coordinate biomass suppliers and users.
- Guidance should be provided to farmers on the ***most sustainable use of surplus straw*** (and other crop residues) identifying where improving soil structure and organic matter content by incorporation in the field may be a higher environmental priority than using straw as a biomass feedstock. There is a range of appropriate uses for straw which can be made available sustainably and these can be promoted more actively once the position is clearer.
- Policy is needed to ***encourage the multi-functional management of undermanaged woodlands and the restoration of planted ancient woodland sites (PAWS)*** with a bioenergy dimension, while adhering to the requirement for sustainable management set out in the UK Forestry Standard. Policy support in this area would include revised provision of management grants, training and marketing support and support targeted specifically at owners of undermanaged woodland, especially on farms that are currently not reached by Forestry Commission activities. Spatial land use plans are needed to identify where new woodlands would contribute to various environmental objectives, such as habitat restoration and linking up or buffering fragmented woodlands beyond their role as carbon sinks.

Environmentally responsible bioenergy in the EU

National policies will not develop in isolation. Several developments in EU policy will help to frame national measures with regard to domestic and imported feedstocks in the UK and elsewhere. The Commission's position on how to deal with indirect land use change in relation to biofuels is still expected at the time of completion of this report[99]. In addition, the European Commission will decide by the end of 2011 whether to propose harmonised binding sustainability criteria for solid and gaseous biomass. This would facilitate the intra-EU market for sustainable biomass and affect standards developed in the UK.

Questions concerning environmentally responsible bioenergy arise not only in the UK but also in other EU Member States. While the national circumstances and the relative weighting of priority issues will differ across Europe, many of the underlying fundamentals in relation to bioenergy development and the environment are relevant beyond the UK. This is especially so since many countries intend to make extensive use of bioenergy in meeting their 2020 targets under the Renewable Energy Directive, raising significant questions about sustainability. Atanasiu (2010) and recent studies commissioned by the European Commission[100] have shown that bioenergy could contribute more than 50 per cent to meeting the EU's renewable energy target in 2020. While the exact political framework is different in every Member State, the hierarchy of feedstocks set out here is likely to be of relevance in many other contexts as well. The use of genuine waste is clearly to be promoted as the top priority nearly everywhere for example. Nonetheless, some elements of the strategy, such as bringing undermanaged woodlands back into management probably will not be of relevance everywhere, given the large variations in forest ownership and management.

UK policy needs to both develop within an EU framework and inform the wider debate in Europe, showing leadership where this is appropriate. Bioenergy policy is still very much an evolving process: well thought through solutions that are developed now in one country may well find a place in other Member States.

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[99] European Commission (2010). Report COM(2010) 811 final from the Commission of 22 December 2010 on indirect land-use change related to biofuels and bioliquids, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0811:FIN:EN:PDF.

[100] See http://www.ecn.nl/docs/library/report/2010/e10069_summary.pdf, stating that biomass will make up 19 per cent of total renewable electricity in the year 2020, 78 per cent of total renewable heating and cooling in 2020 and 89 per cent of total renewable energy in transport. Taken together this would lead to a bioenergy share out of total renewable energy use of over 50 per cent.

REFERENCES

Adams, P W, Hammond, G P, McManus, M C and Mezzullo, W G (2011). Barriers to and drivers for UK bioenergy development. *Renewable and Sustainable Energy Reviews* 15, pp1217-1227.

ADAS (2008). *Addressing the land use issues for non-food crops, in response to increasing fuel and energy generation opportunities*. NNFCC project 08-004, http://www.nnfcc.co.uk/tools/addressing-the-land-use-issues-for-non-food-crops-in-response-to-increasing-fuel-and-energy-generation-opportunities-nnfcc-08-004.

ARUP (2011). *Review of the generation costs and deployment potential of renewable electricity technologies in the UK, Study report for DECC*. http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renew_obs/1834-review-costs-potential-renewable-tech.pdf.

Atanasiu, B (2010). *Flash Forward on Bioenergy in 2020: Facts and uncertainties on bioenergy role in the National Renewable Energy Action Plans*. http://www.ieep.eu/assets/753/bioenergy_in_NREAPs.pdf.

Bowyer, C (2011). *Anticipated indirect land use change associate with expanded use of biofuels and bioliquids in the EU - an analysis of the National Renewable Energy Action Plans*. http://www.ieep.eu/assets/786/Analysis_of_ILUC_Based_on_the_National_Renewable_Energy_Action_Plans.pdf.

Bowyer, C, Baldock, D, Tucker, G, Valsecchi, C, Lewis, M, Hjerp, P and Gantioler, S (2009). *Positive Planning For Onshore Wind: Expanding Onshore Wind Energy Capacity While Conserving Nature*, http://www.rspb.org.uk/Images/Positive%20Planning%20for%20Onshore%20Wind_tcm9-213280.pdf.

Bloomberg New Energy Finance (2010). *Next-generation ethanol and biochemicals: what's in it for Europe?* http://www.bioenergy.novozymes.com/files/documents/BNEF_report_nextgeneration_biofuels.pdf.

Committee on Climate Change (2011). *The Renewable Energy Review*, http://hmccc.s3.amazonaws.com/Renewables%20Review/The%20renewable%20energy%20review_Printout.pdf.

Currie, F (2006). 'England woodland Biodiversity Action Plan (BAP) targets and coppice', in Shepley, A (ed) Twenty-first century coppice; 2006 conference report, Wood Education Programme Trust, Cumbria, pp.7–8.

DBFZ (2010). *Monitoring zur Wirkung des Erneuerbare-Energien-Gesetz (EEG) auf die Entwicklung der Stromerzeugung aus Biomasse*, Deutsches BiomasseForschungsZentrum, http://www.dbfz.de/web/fileadmin/user_upload/3330002_Stromerzeugung_aus_Biomasse_3_Zwischenbericht_.pdf.

DECC (2009). *The UK Renewable Energy Strategy*. Crown Copyright, London, UK.

DECC (2010). *Renewable and Low-Carbon Capacity Assessment Methodology: Methodology for the English Regions*. SQW Energy. http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/ored/1_20100305105045_e_@@_methodologyfortheenglishregions.pdf.

DECC and Defra (2011). *Anaerobic Digestion Strategy and Action Plan - A commitment to increasing energy from waste through Anaerobic Digestion*, http://www.defra.gov.uk/publications/files/pb13541-anaerobic-digestion-strategy110614.pdf.

DECC (2011). *UK Renewable Energy Roadmap*, http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2167-uk-renewable-energy-roadmap.pdf.

Defra (2007). *UK Biomass Strategy* (May 2007). Crown copyright, London, UK.

Delzeit (2011). *Modelling Regional Maize Markets for Biogas Production in Germany: The Impact of Different Policy Options on Environment and Transport Emissions*. Doctoral dissertation prepared at the Institute for Food and Resource Economics at the University of Bonn submitted on 21 July 2010, http://hss.ulb.uni-bonn.de/2011/2390/2390.pdf.

Delzeit, R, Holm-Müller, K and Britz, W (2011). *Ökonomische Bewertung des Erneuerbare Energien Gesetzes zur Förderung von Biogas*. Kiel Working Paper No. 1682, Kiel Institute for the World Economy.

Ecofys (2010). *Evaluation of improvements in end-conversion efficiency for bioenergy production*. Final report. Study commissioned by the EU Commission, http://ec.europa.eu/energy/renewables/transparency_platform/doc/2010_report/2010_02_25_report_conversion_efficiency.pdf.

Ellis, S (2006) 'Coppice management for butterflies', in Shepley, A (ed) Twenty-first century coppice; 2006 conference report, Wood Education Programme Trust, Cumbria, pp21–31.

ENDS (2011a). *Study links palm oil plantations to destruction of peatland*, theENDSreport Issue 434, March, p32.

ENDS (2011b). *Biomass plants bypassing UK supply chain*, the ENDSreport Issue 437, June 2011, pp6-7.

English Nature (2005). *The Importance of Livestock Grazing for Wildlife Conservation*. English Nature, Peterborough.

Environment Agency (2009a). *Biomass: Carbon sink or carbon sinner*? http://www.environment-agency.gov.uk/static/documents/Leisure/Biomass__carbon_sink_or_carbon_sinner_summary_report.pdf.

Environment Agency (2009b). *Minimising greenhouse gas emissions from biomass energy generation*. Science Report. http://www.environment-agency.gov.uk/static/documents/Research/Minimising_greenhouse_gas_emissions_from_biomass_energy__generation.pdf.

Environmental Resources Management (ERM) (2006). *Carbon Balances and Energy Impacts of the Management of UK Wastes*, Final Report for Defra R&D Project WRT 237. http://www.fcrn.org.uk/sites/default/files/ERM_Carbon_balances_and_energy_impacts_of_waste.pdf.

European Environment Agency, EEA (2006). *How much bioenergy can Europe produce without harming the environment?* EEA report No 7/2006, Copenhagen.

Forestry Commission (2004). *The United Kingdom Forestry Standard*. Forestry Commission, Edinburgh.

Forestry Commission England (2007). *A Wood Fuel Strategy for England*. http://www.forestry.gov.uk/pdf/fce-woodfuel-strategy.pdf/$FILE/fce-woodfuel-strategy.pdf.

Forestry Commission (2009). *The Scottish Government's Rationale For Woodland Expansion.* http://www.forestry.gov.uk/pdf/ForestExpansion.pdf/$FILE/ForestExpansion.pdf.

Forestry Commission England (2010). '*Wood Fuel Development Guidance' Issue 03*. http://www.biomassenergycentre.org.uk/pls/portal/docs/PAGE/BEC_HOME/09430-WOODFUELFINAL%20DOC-REVC%20SMALL.PDF.

Forestry Commission England (2011). *Wood Fuel Implementation Plan 2011 – 2014*. http://www.forestry.gov.uk/pdf/FCE_WIP_Web.pdf/$FILE/FCE_WIP_Web.pdf.

Fuller, R J, Noble, D G, Smith, K W and Vanhinsbergh, D (2005). 'Recent declines in populations of woodland birds in Britain: a review of possible causes', British Birds, 98: 116–143.

Gove, B, Flower, K A and Bradbury, R B (2010). *A review of environmental consequences of biomass production for UK energy consumption*. RSPB Research Report No. 38, Sandy: RSPB.

Gurnell, J, Hicks, M and Whitbread, S (1992). 'The effects of coppice management on small mammal populations', in Buckley, G P (ed) Ecology and management of coppice woodlands, Chapman & Hall, London, pp213–232.

Hogg, D, Barth, J, Schleiss, K and Favoino, E (2007). *Dealing with Food Waste in the UK*, Report by eunomia for WRAP, http://www.wrap.org.uk/downloads/Dealing_with_Food_Waste_-_Final_-_2_March_07.a6242c2c.3603.pdf.

Hossell, J, Clemence, B, Wright, B, Edwards, R and Juppenlatz, Z (2006). *Potential impacts of future renewable energy policy on UK biodiversity*. Ref: CR0295. ADAS.

Howes, P, Bates, J, Landy, M, O'Brien, S, Herbert, R, Matthews, R and Hogan, G (2011). *UK and Global bioenergy resources and prices*, Final report for DECC, http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/policy/1464-aea-2010-uk-and-global-bioenergy-report.pdf.

IEEP and Alterra (2010). *Reflecting environmental land use needs into EU policy: preserving and enhancing the environmental benefits of "land services": soil sealing, biodiversity corridors, intensification / marginalisation of land use and permanent grassland.* Final report to the European Commission, DG Environment on Contract ENV.B.1/ETU/2008/0030. Institute for European Environmental Policy / Alterra Wageningen UR.

Kirby, K J, Smart, S M, Black, H I K, Bunce, R G H, Corney, P M and Smithers, R J (2005). 'Long term ecological change in British woodlands (1971–2001)', English Nature Reports, Number 653.

Kretschmer, B (2011). *The Land-Use Implications of EU Bioenergy Policy: Going Beyond ILUC*. http://www.ieep.eu/publications/2011/01/the-land-use-implications-of-eu-bioenergy-policy-going-beyond-iluc.

Lawton, J H, Brotherton, P N M, Brown, V K, Elphick, C, Fitter, A H, Forshaw, J, Haddow, R W, Hilborne, S, Leafe, R N, Mace, G M, Southgate, M P, Sutherland, W J, Tew, T E, Varley, J and Wynne, G R (2010). *Making Space for Nature: a review of England's wildlife sites and ecological network.* Report to Defra.

Mainstone, C P, Dils, R M and Withers, P J A (2008). Controlling sediment and phosphorous transfer to receiving waters - a strategic management perspective for England and Wales. Journal of Hydrology, No 350, pp131-143.

McKechnie, J, Colombo, S, Chen, J, Mabee, W and MacLean, H L (2011). Forest Bioenergy or Forest Carbon? Assessing Trade-Offs in Greenhouse Gas Mitigation with Wood-Based Fuels. *Environmental Science and Technology*, 45, pp789-795.

Melville, N (2010). *Developing Reed as a Wetland Product in the Humberhead Levels*. RPSB, July 2010.

NWDA (2010). Northwest renewable and low carbon energy capacity and deployment. Project report August 2010, Northwest Regional Development Agency, http://www.nwriu.co.uk/pdf/Northwest%20Renewable%20and%20Low%20Carbon

%20Energy%20Capacity%20and%20Deployment%20-%20Final%20Report%20September%202010.pdf.

Peterken, G F, Baldock, D and Hampson, A (1995). *A forest habitat network for Scotland*. Scottish Natural Heritage Research, Survey and Monitoring Report. No 44.

Regen SW (2010). *The South West Renewable Energy Resource Assessment: Methodological Report*. A report to the Department of Energy & Climate Change. November 2010, http://regensw.s3.amazonaws.com/south_west_renewable_energy_resource_assessment_methodological_report_november_2010_3ab46cc2726f0a25.pdf.

RELU (2009). *Assessing the social, environmental and economic impacts of increasing rural land use under energy crops*. Note No. 9 September 2009, http://www.relu.ac.uk/news/policy%20and%20practice%20notes/Karp/Karp.pdf.

RELU (2011) *Farm diversification into energy production by anaerobic digestion. Policy and practice note 26.* The Rural Economy and Land Use Programme, Newcastle-upon-Tyne. http://www.relu.ac.uk/news/policyandpracticenotes.htm.

Robinson, D O (2009). A review of biodiversity impacts following increased woodfuel harvesting in ancient woodland in England; a critique of the Forestry Commission's 2007 Woodfuel Strategy for England. MSc/DIC Imperial College.

Sheate, W, Eales, R, Baker, J, Stafford, J, Barker, A, van Der Burgt, N and Rosário Partidário, M (2011). *A Natural Planning Framework: Putting the Natural Environment at the Heart of the National Planning Framework for England*. Report for the RSPB by Collingwood Environmental Planning Ltd.

Sherrington,_C, Bartley, J and Moran, D (2008). Farm-level constraints on the domestic supply of perennial energy crops in the UK, *Energy Policy* 36, pp2504-2512.

South East Planning Partnership Board (2010). Review of Renewable and Decentralised Energy Potential in South East England. Report prepared by Land Use Consultants and TV Energy, June, 2010, http://webarchive.nationalarchives.gov.uk/20100908090945/http://se-partnershipboard.org.uk/pdf/nat_res/potential_re_in_se.pdf.

Townshend, D, Stace, H and Radley, D (2004). State of Nature: Lowlands - Future Landscapes for Wildlife. English Nature, Peterborough.

Tristram Stuart (2009). *Waste: uncovering the global food scandal*. Penguin, ISBN: 9780141036342.

Tucker, G, Bassi, S, Anderson, J, Chiavari, J, Casper, K and Fergusson, M (2008). *Provision of Evidence of the Conservation Impacts of Energy Production*. Institute for European Environmental Policy (IEEP), London.

ANNEX A INTRODUCING BIOENERGY, ITS SOURCING AND USES

Bioenergy is energy produced from biomass. According to the IEA/OECD, bioenergy is the energy produced from 'material which is directly or indirectly produced by photosynthesis and which is utilised as a feedstock in the manufacture of fuels and substitutes for petrochemical and other energy intensive products'[101]. Alternatively, the UK Biomass Strategy (Defra, 2007) defines bioenergy as: 'Biomass is derived from energy crops (such as short rotation coppice and miscanthus), forestry manures and slurries, and organic waste such as food waste. It can be used to generate electricity and or heat and to produce transport fuel. Such energy is known bioenergy'. These definitions show that bioenergy is a very broad concept that includes energy derived from all sorts of different biomass sources, ranging from waste products to dedicated energy cropping

Bioenergy comes in different forms; most notably it can be gaseous, liquid and solid. For the purpose of this report we will deploy the definitions of different forms of bioenergy as defined in the EU Renewable Energy Directive:

- **biomass** means the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste;
- **bioliquids** means liquid fuel for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass; and
- **biofuels** means liquid or gaseous fuel for transport produced from biomass.

In line with the wide range of different biomass inputs, there is a wide range of conversion processes to generate a variety of different forms of energy and for different purposes. An overview of the different supply chains from the original biological resource through supply systems to conversion (treatment) and end use is given in Figure 1 of the main report.

Supply chains and their associated technologies can be classified in different ways with three critical elements being the original feedstock, the conversion process and the final energy use. Within these chains the different existing technologies are at different stages of market maturity, an overview of which is given in Table 2 below.

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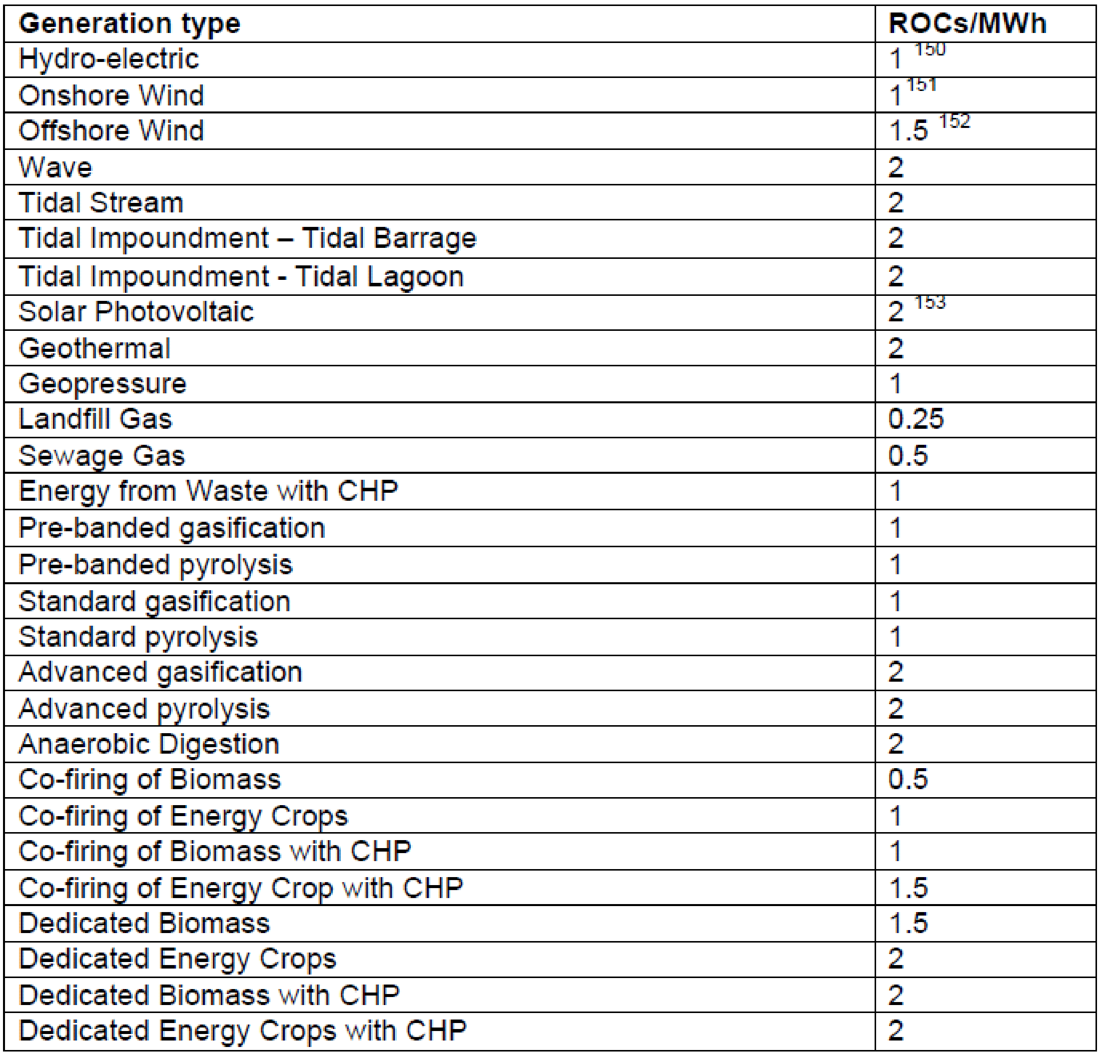
[101] IEA Bioenergy: http://www.ieabioenergy.com/IEABioenergy.aspx

Table 2. Major technologies in biomass to energy conversion (Ecofys, 2010)

Type of generated energy	Feedstock type	Conversion process	Technology maturity
Heat generation	Solid	Boiler	Yes
	Gaseous, liquid	Boiler	No
Combined heat and power (CHP)	Solid	Boiler-steam turbine	yes
		Pyrolysis reactor-diesel engine	No
		Pyrolysis reactor-gasifier	No
		Torrefaction reactor-boiler-steam turbine	No
	Solid and/or liquid	Gasifier-boiler-steam turbine	No
		Gasifier-gas engine	No
		Gasifier-gas turbine-boiler-steam turbine	No
		Digester-gas engine	Yes
		Digester-gas turbine-boiler-steam turbine	No
	Liquid	Diesel engine	Yes
		Boiler-steam turbine	No
	Waste	Landfill-gas engine	Yes
		Landfill-gas turbine-boiler-steam turbine	No
Co-firing	Solid	Boiler (power plant)-steam turbine	Yes
		Gasifier (power plant)-gas turbine-boiler-steam turbine	Yes
	Liquid	Boiler (power plant)-steam turbine	Yes

ANNEX B SUPPORT UNDER THE RENEWABLE OBLIGATION ORDER AND THE FEED IN TARIFFS

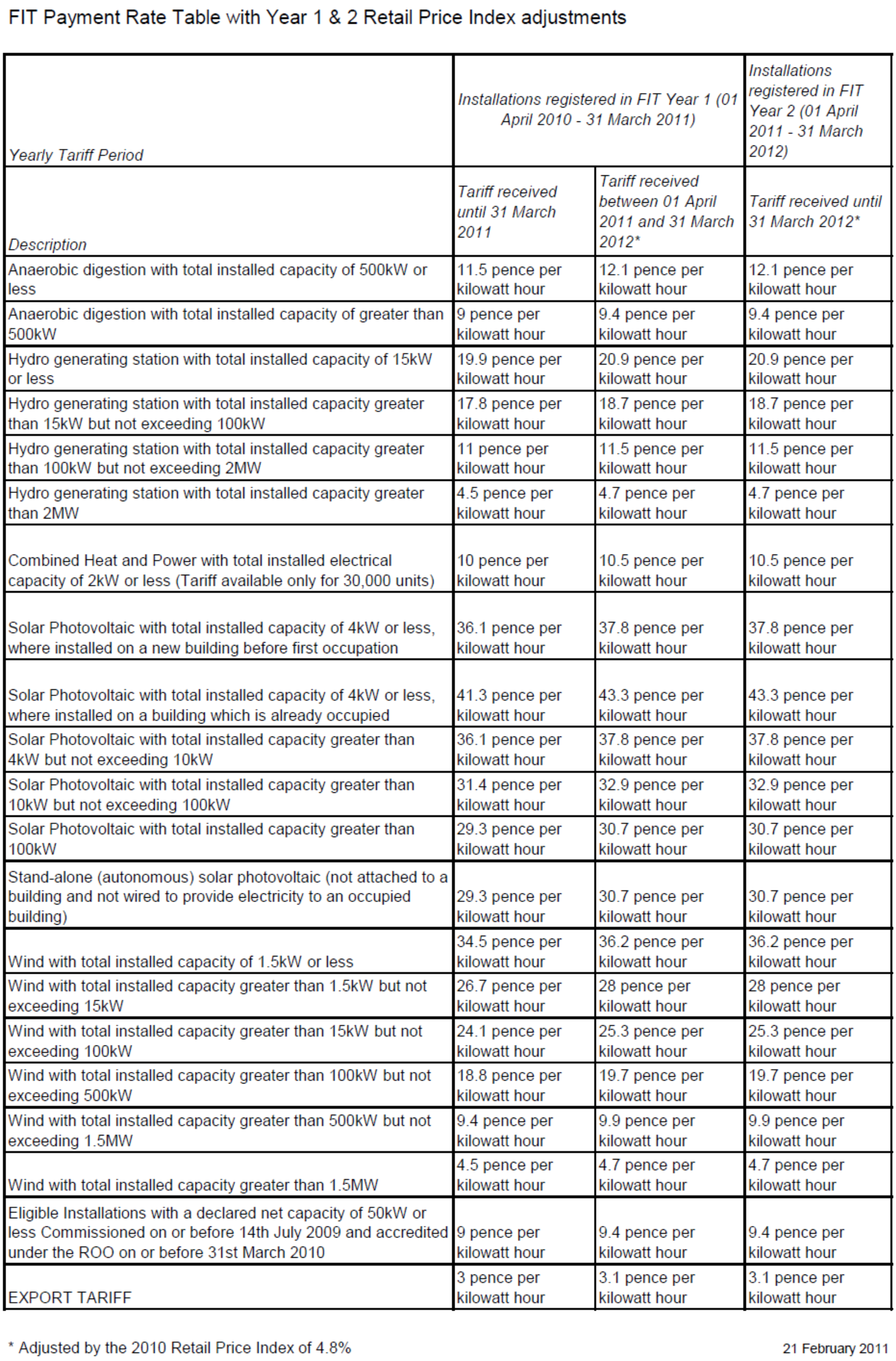
Table A1. Different support levels under the UK Renewables Obligation



Generation type	ROCs/MWh
Hydro-electric	1 [150]
Onshore Wind	1 [151]
Offshore Wind	1.5 [152]
Wave	2
Tidal Stream	2
Tidal Impoundment – Tidal Barrage	2
Tidal Impoundment - Tidal Lagoon	2
Solar Photovoltaic	2 [153]
Geothermal	2
Geopressure	1
Landfill Gas	0.25
Sewage Gas	0.5
Energy from Waste with CHP	1
Pre-banded gasification	1
Pre-banded pyrolysis	1
Standard gasification	1
Standard pyrolysis	1
Advanced gasification	2
Advanced pyrolysis	2
Anaerobic Digestion	2
Co-firing of Biomass	0.5
Co-firing of Energy Crops	1
Co-firing of Biomass with CHP	1
Co-firing of Energy Crop with CHP	1.5
Dedicated Biomass	1.5
Dedicated Energy Crops	2
Dedicated Biomass with CHP	2
Dedicated Energy Crops with CHP	2

Source: Taken from the UK NREAP, p.114

Table A2. Generation tariffs under the Feed in Tariffs scheme (1 April 2010 – 31 March 2013)



FIT Payment Rate Table with Year 1 & 2 Retail Price Index adjustments

Yearly Tariff Period	*Installations registered in FIT Year 1 (01 April 2010 - 31 March 2011)*		*Installations registered in FIT Year 2 (01 April 2011 - 31 March 2012)*
Description	*Tariff received until 31 March 2011*	*Tariff received between 01 April 2011 and 31 March 2012**	*Tariff received until 31 March 2012**
Anaerobic digestion with total installed capacity of 500kW or less	11.5 pence per kilowatt hour	12.1 pence per kilowatt hour	12.1 pence per kilowatt hour
Anaerobic digestion with total installed capacity of greater than 500kW	9 pence per kilowatt hour	9.4 pence per kilowatt hour	9.4 pence per kilowatt hour
Hydro generating station with total installed capacity of 15kW or less	19.9 pence per kilowatt hour	20.9 pence per kilowatt hour	20.9 pence per kilowatt hour
Hydro generating station with total installed capacity greater than 15kW but not exceeding 100kW	17.8 pence per kilowatt hour	18.7 pence per kilowatt hour	18.7 pence per kilowatt hour
Hydro generating station with total installed capacity greater than 100kW but not exceeding 2MW	11 pence per kilowatt hour	11.5 pence per kilowatt hour	11.5 pence per kilowatt hour
Hydro generating station with total installed capacity greater than 2MW	4.5 pence per kilowatt hour	4.7 pence per kilowatt hour	4.7 pence per kilowatt hour
Combined Heat and Power with total installed electrical capacity of 2kW or less (Tariff available only for 30,000 units)	10 pence per kilowatt hour	10.5 pence per kilowatt hour	10.5 pence per kilowatt hour
Solar Photovoltaic with total installed capacity of 4kW or less, where installed on a new building before first occupation	36.1 pence per kilowatt hour	37.8 pence per kilowatt hour	37.8 pence per kilowatt hour
Solar Photovoltaic with total installed capacity of 4kW or less, where installed on a building which is already occupied	41.3 pence per kilowatt hour	43.3 pence per kilowatt hour	43.3 pence per kilowatt hour
Solar Photovoltaic with total installed capacity greater than 4kW but not exceeding 10kW	36.1 pence per kilowatt hour	37.8 pence per kilowatt hour	37.8 pence per kilowatt hour
Solar Photovoltaic with total installed capacity greater than 10kW but not exceeding 100kW	31.4 pence per kilowatt hour	32.9 pence per kilowatt hour	32.9 pence per kilowatt hour
Solar Photovoltaic with total installed capacity greater than 100kW	29.3 pence per kilowatt hour	30.7 pence per kilowatt hour	30.7 pence per kilowatt hour
Stand-alone (autonomous) solar photovoltaic (not attached to a building and not wired to provide electricity to an occupied building)	29.3 pence per kilowatt hour	30.7 pence per kilowatt hour	30.7 pence per kilowatt hour
Wind with total installed capacity of 1.5kW or less	34.5 pence per kilowatt hour	36.2 pence per kilowatt hour	36.2 pence per kilowatt hour
Wind with total installed capacity greater than 1.5kW but not exceeding 15kW	26.7 pence per kilowatt hour	28 pence per kilowatt hour	28 pence per kilowatt hour
Wind with total installed capacity greater than 15kW but not exceeding 100kW	24.1 pence per kilowatt hour	25.3 pence per kilowatt hour	25.3 pence per kilowatt hour
Wind with total installed capacity greater than 100kW but not exceeding 500kW	18.8 pence per kilowatt hour	19.7 pence per kilowatt hour	19.7 pence per kilowatt hour
Wind with total installed capacity greater than 500kW but not exceeding 1.5MW	9.4 pence per kilowatt hour	9.9 pence per kilowatt hour	9.9 pence per kilowatt hour
Wind with total installed capacity greater than 1.5MW	4.5 pence per kilowatt hour	4.7 pence per kilowatt hour	4.7 pence per kilowatt hour
Eligible Installations with a declared net capacity of 50kW or less Commissioned on or before 14th July 2009 and accredited under the ROO on or before 31st March 2010	9 pence per kilowatt hour	9.4 pence per kilowatt hour	9.4 pence per kilowatt hour
EXPORT TARIFF	3 pence per kilowatt hour	3.1 pence per kilowatt hour	3.1 pence per kilowatt hour

* Adjusted by the 2010 Retail Price Index of 4.8%

21 February 2011

Source: http://www.ofgem.gov.uk/Sustainability/Environment/fits/Documents1/Feed-in%20Tariff%20Year%202%20tariff%20table%20adjusted%20for%20Retail%20Price%20Index.pdf.

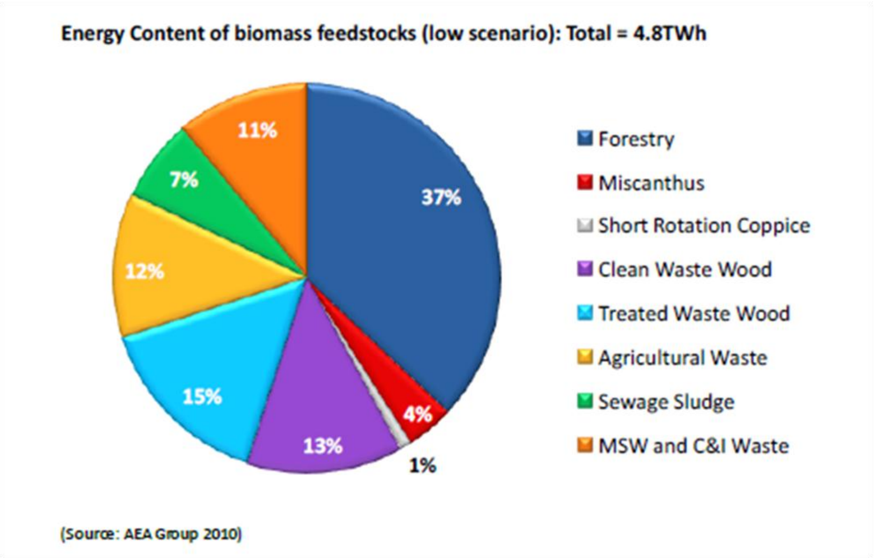
ANNEX C ESTIMATION OF REGIONAL BIOMASS POTENTIALS

DECC (2010) provides a methodology addressed at English regions to estimate their renewable and low-carbon energy capacity. The methodological guidance neither covers biofuels nor bioliquids (for use in heating and power generation) as these compete with other biomass fuel categories and are therefore not considered additional and are often imported. We are aware of three completed studies, whose main results are presented here. A caveat are the varying categories of biomass considered and underlying assumptions applied to derive biomass potentials. Types of plant biomass considered are:

- managed woodland;
- dedicated energy crops;
- industrial woody waste;
- agricultural arisings (straw);
- wet organic waste (manure and slurry, food and drink waste);
- dry organic waste (poultry litter);
- municipal solid waste (MSW);
- commercial and industrial waste (C&IW);
- landfill gas and sewage gas;
- co-firing of biomass (note: a large share of biomass co-fired will be imported, so including this category distorts the domestic potential).

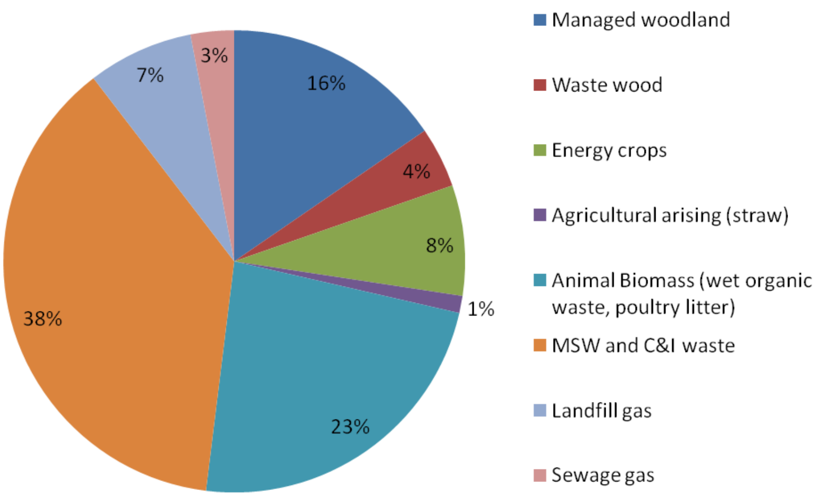
The figures below give an indication about the regional relative importance of biomass feedstocks for energy use. Waste based biomass sources play a strong role. The South West, however, displays a large potential of wood derived sources. The comparability is, however, hampered by the fact that the South West study has not assessed the potential of landfill gas while the others have. As the south west study was initiated prior to the finalisation of the DECC methodology, it diverges from it in some instances. Regen SW (2010, p.20) gives an overview of the differences in biomass categories.

Figure A1. Energy content of bioenergy resources for the South West (in TWh)



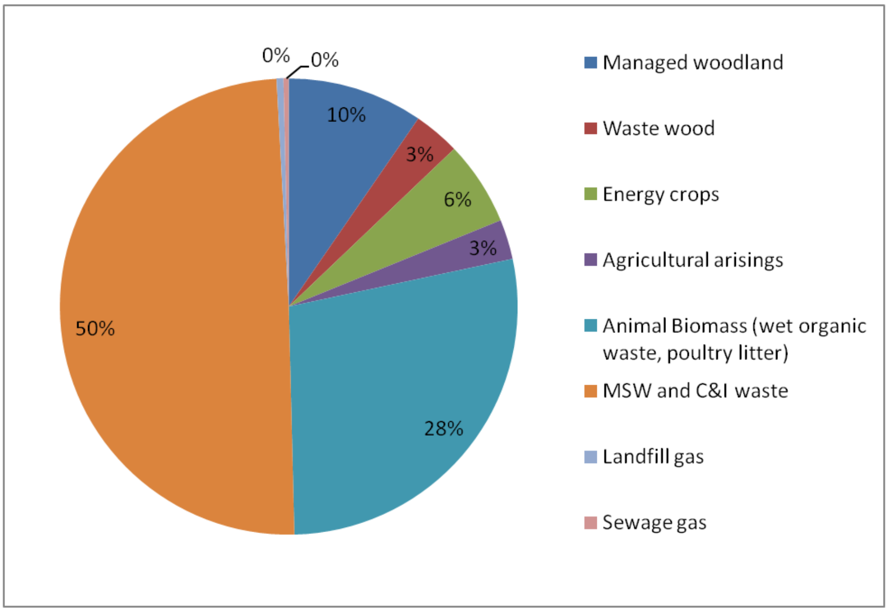
Source: Regen SW (2010, p.21). All feedstocks are assumed to be similar to current levels with exception of energy crops where the level is projected to 2020 in line with the *low* scenario in DECC (2010) ('assume new crops will only be planted to the extent of submitted application to the Energy Crop Scheme (ECS) for 2010'). Note that landfill gas is not assessed. The total potential of 4.8TWh (terawatt hours) can be translated into an estimated potential of 68MW (megawatt) of electricity and 1497MW of heat capacity. MSW is municipal solid waste and C&I is commercial and industrial waste.

Figure A2. Energy content of bioenergy resources for the North West (in MW)



Source: Based on Table 1 in NWDA (2010). We combined categories to make the figure more comparable to the figure for the south west. The total accessible resource is 920 MW. The 2020 energy crop potential is estimated in line with the *medium* scenario of the DECC (2010) methodology. We excluded the potential for co-firing as UK co-firing needs will be largely met by imported biomass. The methodology in DECC (2010) in relation to co-firing is in fact more a 'biomass resource need' estimate rather than a resource potential as it is derived from applying a 10 per cent co-firing share to total regional capacity of coal and oil fired plants.

Figure A3. Energy content of bioenergy resources for the South East (in MW)



Source: Based on Table 3.32 in South East Planning Partnership Board (2010, p93). We combined categories to make the figure more comparable to the other figures. The total available resource is 14,945 MW. We excluded the potential for co-firing as UK co-firing needs will be largely met by imported biomass. The methodology in DECC (2010) in relation to co-firing is in fact more a 'biomass resource need' estimate rather than a resource potential as it is derived from applying a 10 per cent co-firing share to total regional capacity of coal and oil fired plants. The 2020 energy crop potential is estimated in line with the *medium* scenario of the DECC (2010) methodology (assumes that all abandoned land and pasture will be planted with energy crops).