UK Biomass Strategy

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Joint Defra/DTI/DFT Ministerial Foreword

Publication of the Government's Biomass Strategy fulfils an important obligation in our response to the 2005 Biomass Task Force Report.

We have made a firm commitment to tackle climate change. This is an urgent problem which requires a co-ordinated strategic approach. The Climate Change Bill, published in draft in March 2007, sets out a proposed UK target of at least 60% cuts in carbon dioxide emissions by 2050 and a strong new system of carbon budgeting. We need to explore every avenue for achieving these cuts in emissions in sustainable ways over the decades ahead.

We agree with this assessment. This strategy complements the Energy White Paper published today. It also complements the Government's response to the two year progress report on the Non-Food Crops Strategy and the Government's soon to be published revised Waste Strategy. In the international context it reflects thinking in the EU Biomass Action Plan. It also builds on the work of the Global Bioenergy Partnership and the International Energy Agency through its Bioenergy Implementing Agreement as well as the work on biofuels with Brazil, South Africa and Mozambique.

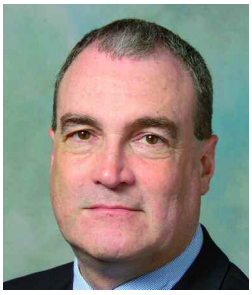
This strategy draws on detailed work to evaluate the contribution biomass can play in meeting our future energy and industrial material needs in a sustainable way. Biomass has the potential to make a valuable contribution in a number of areas such as heat and electricity generation and in the development of greener fuels for transport and sustainable industrial products. In many of these areas biomass can be used as a low carbon, sustainable replacement for fossil fuels.

The implications for the UK of the recent agreement on EU targets for renewables and biofuels are still subject to further work and negotiation. Consequently this strategy cannot set out in detail the role biomass will play in meeting those targets.

However the broad approach we will need to adopt to meet these targets and realise our ambitions is clear. Biomass supplies will need to increase significantly and sustainably. This represents an important challenge for all parts of the supply chain and will bring new opportunities for many, including the farming industry. Managed well, changes in land use to deliver biomass can also give multiple environmental benefits. To achieve this, biomass production must be at least as sustainable, in terms of its wider environmental impacts, as is now the case for "normal" agricultural production. We are committed to this process and this strategy sets out the measures we have put in place to achieve these outcomes. We also welcome the important role industry has played in the development of policies and mechanisms to increase the use of biomass.

This strategy reflects targets which apply to all parts of the country. However many of the detailed provisions described will apply primarily in England. This reflects the development of detailed strategies to deal with the different circumstances applying in Scotland, Wales and Northern Ireland. However all parts of the UK, in common with other countries across the world, are committed to the development of biomass as an essential sustainable resource.

This strategy makes a vitally important contribution to tackling a global problem. We have set out our plans and look forward to working with industry representatives to deliver our long term objectives.



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Executive Summary

This strategy, published with the Government's Energy White Paper[1], meets the commitment made in the Energy Review (2006) and in the Government's response to the 2005 Biomass Task Force Report and brings together current UK Government policies on biomass for energy, transport and industry. It also builds on the aims, objectives and vision in the 2004 Defra/DTI strategy for non-food crops and uses. The Biomass Strategy acknowledges the importance of fuels sourced from biomass in tackling climate change. Biomass will have a central role to play in meeting the EU target of 20% renewable energy by 2020. The Climate Change Bill, published in draft in March 2007, sets out a proposed UK target of at least 60% cuts in carbon dioxide emissions by 2050 and a strong new system of carbon budgeting. We need to explore every avenue for achieving these cuts in emissions in sustainable ways over the decades ahead.

This strategy reflects UK targets and policy objectives, and acknowledges that separate strategies have been or are being developed to address the specific conditions that apply in Scotland, Wales and Northern Ireland.

Biomass is renewable and generally has low carbon characteristics. Where biomass is produced and processed with due regard to sustainability and carbon savings, it can be carbon-neutral (the CO_2 released when it is used to create energy can be offset by the CO_2 it consumes when growing). Biomass is also very versatile and can be used as fuel across the energy spectrum for electricity, heat and transport as well as the production of industrial material. At current usage levels biomass can be considered as an untapped resource.

The Government's strategy for biomass is intended to:

- realise a major expansion in the supply and use of biomass in the UK
- facilitate the development of a competitive and sustainable market and supply chain
- promote innovation and low-carbon technology development so biomass can deliver relatively higher energy yields
- contribute to overall environmental benefits and the health of ecosystems through the achievement of multiple benefits from land use
- facilitate a shift towards a bio-economy through sustainable growth and development of biomass use for fuels and renewable materials
- maximise the potential of biomass to contribute to the delivery of our climate change and energy policy goals: to reduce CO_2 emissions, and achieve a secure, competitive and affordable supply of fuel.

Biomass production

Delivery of this strategy will require a major expansion of biomass use and sustainable supply. It is acknowledged that increasing the supply of biomass will have implications for land use, biodiversity, landscape and a range of other environmental factors. We believe that a significant increase in sustainable UK biomass production, taking full account of the lessons we have learnt from more traditional forms of agriculture and our emerging understanding of how ecosystems work, is achievable. We will seek to deliver an expansion of biomass production in a way which is consistent with an enhanced, sustainable approach to land

1 www.dti.gov.uk/energy/whitepaper

management. This will deliver multiple environmental benefits and enhance the health of ecosystems. We have looked carefully at the supply side. We believe there is significant potential to expand the UK supply of biomass without any detrimental effect on food supplies and in a sustainable manner by:

- sourcing an additional 1 million dry tonnes of wood per annum from currently unmanaged woodland in England, and from increasing the recovery of wood for energy from managed woodland and other sources of wood waste products across the UK
- increasing the amount of perennial energy crops produced in the UK to meet market demands – with the potential to use up to a further 350,000 hectares across the UK by 2020[2]. This brings the total land availability for biofuel and energy crops to around 1 million hectares, equivalent to 17% of total UK arable land
- increasing supply from organic waste materials such as manures and slurries, certain organic wastes, source separated waste biomass and waste derived Solid Recovered Fuels (SRF)

By expanding existing biomass supplies in this way we estimate the potential future biomass resource in the UK to be a total of approximately 96.2 TWh (8.3 Mtoe). If it is assumed UK biofuel crop production can supply half of the 5% (by volume) target for 2010[3] this gives a total predicted theoretical biomass resource level in the UK of around 10.0 Mtoe[4].This compares with a total UK energy need of currently 165 Mtoe[5]. These estimates could be considered conservative.

It is clear that imports will continue to play a significant role in meeting UK energy needs, particularly for transport fuels and co-firing (electricity produced from fossil fuels co-fired with biomass). It is estimated that current annual imports account for the equivalent of some 54TWh. This figure is expected to grow.

We are keenly aware of the environmental risks from unsustainable production and damaging changes of land use. We fully support the EU approach of linking potential increases in biofuel targets to sustainability criteria. It is acknowledged that increasing the supply of biomass will have implications for land use, biodiversity, the environment and the landscape. Imports will have an important role to play in meeting the demand for biomass this strategy will create and here we are taking steps to ensure sustainable practices are at the heart of our policies.

Future decisions on biomass production will require a long term view. Climate change is expected to have an impact on the biomass that will flourish in the UK over the next 50-60 years. Some existing biomass sources will cease to be viable in certain locations while other new species can be introduced. Other sources of biomass such as certain wastes are suitable for energy recovery, including through anaerobic digestion and have an increasingly important role to play. This will expand biomass energy production and reduce the carbon impact of waste management.

Innovation to improve efficiencies

Biomass supply can also be increased through technology innovation, which can improve the efficiency of the energy conversion and reduce the delivered amount and cost of the fuels used. The technology used for heat and power generation is primarily well-established combustion technology. This can provide heat and power reliably but at low efficiencies when compared with equivalent larger-scale fossil fuel generation technologies. Further research is required into potentially more efficient energy generation technologies, such as gasification and pyrolysis.

Both Government and industry are already investing strongly in energy innovation. This includes fundamental research through to the deployment of technologies. This investment is set to rise. A new public/private sector joint venture, the Energy Technologies Institute, will be established. This will have a budget of up to £1bn over the next decade for R&D in low carbon energy technologies and demand management. A new Environmental Transformation Fund (ETF) is also being established to invest in low-carbon energy, including the demonstration and deployment of energy technologies such as bioenergy.

Supply chain development

We are committed to the ongoing development of biomass supply chains in conjunction with action to

2 Renewables Innovation Review: www.dti.gov.uk/files/file22017.pdf

3 Based on the amount of biofuel feedstocks needed to supply 50% of the 5% (by volume) RTFO target, with a 55:45 split between biodiesel and bioethanol.

4 These assessments do not take into account the biofuel production that could be sourced from waste oils which currently are disposed of to landfill or additional straw produced with first generation biofuel feedstocks.

5 Excludes non-energy use of fuels (12.6 Mtoe), final consumption of oil for air, rail and national navigation (16.1 Mtoe) and other primary energy uses not included in the three categories, such as mechanical power, energy for cooking/catering, use by the energy industries and other transformation and distribution losses (17.8 Mtoe).

develop the bioenergy market. We are working closely with the Regional Development Agencies (RDAs) on the development of regional carbon targets. The RDAs also have a key role to play in building the partnerships needed to develop supply chains as an integral part of the regional strategies for renewable energy development. This will facilitate the development of supply chains best suited to local needs and resources.

Biomass for energy

This strategy also emphasises our wish to increase the use of biomass as an energy source, given its importance in the transport, heat and electricity sectors. We have looked across the different energy sectors in order to establish which represents the most effective use of biomass raw materials. Our analysis shows a clear hierarchy of use in terms of cost of carbon saving (£/tonneC):

- biomass heating is the most effective form of bioenergy, particularly in industrial and commercial applications
- biomass combined heat and power (CHP)
- co-fired electricity in large fossil fuel plants
- dedicated biomass power plant
- transport biofuels

Incentives are already in place to support the use of biomass as a renewable fuel source for heat, electricity, and transport. The nature and level of incentives vary between the different sectors, and include the Renewables Obligation (for electricity supply), the Renewable Transport Fuel Obligation, and grants towards the capital costs of heat, and CHP.

One conclusion of this strategy could be that these incentives should be reordered to reflect this hierarchy of use of biomass. However, such an interpretation would be overly simplistic as it does not take into account the relative importance of biomass fuel sources in delivering climate change goals and targets. For example, despite their higher cost of carbon, transport biofuels are essential to carbon savings in the transport sector for which there are few other options in the short to medium term.

The RTFO, when introduced, will mean that by 2010, 5% of fuels sold on UK forecourts will come from renewable sources. We are committed to increasing the level of the planned RTFO beyond 5% after 2010/11, but only if the following conditions are met:

- biofuels are produced in a sustainable way delivering maximum carbon savings with minimum adverse environmental impacts
- biofuel blends higher than 5% will not lead to mechanical problems in vehicles
- costs to consumers and the wider economy will be acceptable

The hierarchy can nevertheless be applied in part. It will inform consideration of renewable energy targets, and the revisions currently being proposed to the Renewables Obligation, in particular the new system of banding support levels to promote emerging energy technologies. It also points to the need for work on whether further measures can be developed to support renewable heat (and cooling), utilising biomass sources, which the Government undertakes to do.

Defra expenditure on non-food crops will be increased from 2008/2009. The exact details will be determined in the Comprehensive Spending Review (CSR). Funding for Defra's 5-year Bioenergy Capital Grants Scheme and details of the joint DTI/Defra Environmental Transformation Fund (ETF) will also be determined through the CSR.

We intend to monitor delivery of this strategy in collaboration with all stakeholders including farming, industry and environmental interests, regional and local bodies and planners. This will build on the indicators established to monitor the strategy for non-food crops and uses.

1. Introduction

1.1 The work of the Biomass[6] Task Force highlighted the need for a coherent Biomass Strategy. Publication of this strategy addresses that need and meets the commitment made in the Government's response to the Task Force Report[7] and in the UK Energy Review.[8] It also takes account of the Government response to the two year review of the strategy for non-food crops with these activities being brought together under a single renewables programme.

1.2 We agree with the Task Force's conclusion that biomass was an under-utilised resource especially as a source of renewable heat. This strategy outlines our ambition to expand the supply of sustainably produced biomass and to increase the use of biomass to provide energy to generate heat and electricity and (subject to the outcome of current consultations) for transport. It sets out routes for achieving these objectives and addresses the risks especially in relation to changes in land use. The UK Sustainable Development Strategy[9] sets out five guiding principles and these will be applied to the formulation of policy flowing from this strategy.

1.3 This strategy brings together current Government policies on biomass for industry, energy and transport and provides a framework for the development of biomass as a whole. It recognises that EU and wider international policies will have an important influence on the use of biomass. In particular the EU recently agreed:

- a 20% share of renewable energies in overall EU energy consumption by 2020;
- a 10% minimum target to be achieved by all Member States for the share of biofuels in overall EU transport petrol and diesel consumption by 2020, to be introduced in a cost-efficient way. This target is subject to biofuels production being sustainable, second-generation biofuels becoming commercially available and the Fuel Quality Directive being amended accordingly to allow for adequate levels of blending.

Specific renewables targets have still to be agreed for individual Member States. These will take account of different national starting points, including the existing level of renewable energies and the current energy mix. Every Member State will be expected to meet the minimum biofuels target, subject to the caveats above, but will be given discretion to decide on national targets for each specific sector of renewable energies (heating and cooling, electricity and biofuels). While the specific targets that will apply in the UK have yet to be determined, it is clear biomass will have an important role to play in meeting them.

1.4 In publishing this strategy now we are not in a position to set out in detail how we plan to meet the new EU targets. However the need is evident for a significant increase in sustainable biomass production and its use for energy.

1.5 Climate change is both a long-term and urgent challenge. Delivering our policy to tackle climate change is a priority. The policy is focussed on reducing carbon dioxide emissions – by 20% below 1990 levels by 2010 and by 60% by 2050. We are also committed, under the Kyoto Protocol, to reduce our greenhouse gas emissions by 12.5% below 1990 levels by 2008-12 and are on track to achieve this.

1.6 Biomass can play a significant part, not only in reducing net emissions of carbon dioxide but also in mitigating other greenhouse gas emissions especially through the development of anaerobic digestion treatment of manures and slurries and biowaste. Anaerobic digestion produces a biogas that can be used as a renewable energy source, both for heat and power, and as a transport fuel. The treated liquid (or digestate) can be used as a fertiliser. We need to draw on scientific advance and industrial innovation to utilise biomass to meet the increasing demands for sustainable products from renewable sources. This move towards a bio-economy is a key part of our vision for one-planet living under which economies continue to grow sustainably while recognising the environmental limits which face us all.

6 http://www.defra.gov.uk/farm/crops/industrial/energy/biomass-taskforce/pdf/btf-final-execsumm.pdf
7 http://www.defra.gov.uk/farms/crops/industrial/energy/biomass-taskforce/pdf/btfreport-govresponse.pdf
8 http://www.dti.gov.uk/files/file31890.pdf
9 http://www.sustainable-development.gov.uk/publications/uk-strategy/index.htm

1.7 We will continue to deliver our policies and aspirations through close working with public, private sector and community stakeholders. The Regional Development Agencies (RDAs) are using their Regional Economic Strategies to progress towards implementation of the Task Force recommendations. The RDAs will work in partnership with the Forestry Commission (for woody biomass), local authorities and a range of local delivery bodies to identify and support the most appropriate range of activities for facilitation to realise these objectives.

1.8 The Government's response to the Biomass Task Force Report, included a clear commitment to produce a UK Biomass Strategy. However time has moved on rapidly since this commitment was made in July 2006, with the different nations of the UK pressing ahead with the development of action plans and policies to drive forward biomass use. This strategy is intended to complement the work already published in Scotland and Northern Ireland, and the developing policies in Wales, and does not seek to duplicate, pre-empt or replace them. We also acknowledge that the new devolved government administrations may wish to change existing policies or introduce new ones. However this strategy will help set the context where targets, and measures to meet them, have UK wide application and inform thinking within the devolved administrations.

1.9 Key actions taken in England as a result of the commitments made in our response to the Biomass Task Force Report include:

- the launch of a five-year Defra grant scheme for biomass heat and CHP, building on previous support from DTI and the Big Lottery Fund
- confirmation of the intention to support energy crop establishment in the new Rural Development Programmes
- development of strategies for promoting second-generation biofuel technologies
- action to promote biomass alongside other renewables in policies on planning and sustainable communities
- publication of the England Woodfuel Strategy

In addition the overall approach to energy supply set out in the Energy Review (and now taken further in the Energy White Paper) provides underpinning support to our specific objectives for biomass.

1.10 In Northern Ireland the key renewables target of 12% for the amount of electricity to be consumed from renewable sources by 2012 includes a sub-target that 15% of those renewables should be from non-wind sources. While there are no targets against specific sources such as biomass there is nonetheless a significant potential for biomass to contribute. In this context, the major CHP development (2.7MWe/10MWth) at the Balcas sawmill in Co. Fermanagh, part funded by a £2m grant from DTI, is already an exemplar in biomass development: the operation makes the sawmill self-sufficient in electricity while the CHP plant also powers one of the largest biomass pellet production facilities in the British Isles. The pellets are produced using sawdust residues from the main sawmill operation and the operation produces 50,000 tonnes of pellets annually, sufficient to meet the energy needs of 10,000 households.

1.11 The public sector too is leading by example and in this context the Northern Ireland Sustainable Development Strategy[10] includes a target for the Government Estate to be carbon neutral by 2015. Further, the £59m Environment and Renewable Energy Fund[11] established by the Northern Ireland Secretary of State, Peter Hain, in 2006 includes provision for developing the use of biomass to produce heat and power as well as for the associated bioenergy research and infrastructure development.

1.12 In January 2007, the Northern Ireland Department of Agriculture and Rural Development published a Renewable Energy Action Plan.[12] This provides a coherent support framework that will enable the land based rural sector to realise the potential of renewable energy production at a regional level in a balanced and sustainable way. On 4 March 2007, the Government in the Republic of Ireland published a Bioenergy Action Plan[13] which includes among its immediate actions working with Northern Ireland to develop an all-island approach to developing the bioenergy sector over the next three years. This is in line with the all-island approach to overall energy development on the island of Ireland and should help achieve economies in bioenergy development.

10 http://www.ofmdfmni.gov.uk/sustain-develop.pdf
11 http://www.detini.gov.uk/cgi-bin/downdoc?id=1985
12 http://www.dardni.gov.uk/renewable-energy-action-plan-2.pdf
13 http://www.dcmnr.gov.ie/NR/rdonlyres/6D4AF07E-874D-4DB5-A2C563E10F9753EB/27345/BioenergyActionPlan.pdf

1.13 In Scotland a Scottish Biomass Action Plan was published on 19 March 2007.[14] The Scottish Plan aims to:

- provide a summary of a wide range of existing activities, actions and initiatives;
- provide a focus for a strategic co-ordinated approach to developing biomass for energy production across heat, electricity and transport sectors;
- identify roles and responsibilities for government, industry and public stakeholders to develop a vibrant bioenergy industry in Scotland;
- and identify future actions and gaps.

1.14 The Welsh Assembly Government intends to produce, later this year, a Welsh Biomass Energy Strategy which will address issues of supply and demand. This will build on previous biomass schemes in Wales, such as the co-firing of coal and biomass at Aberthaw power station, and the use of biomass boilers to heat the National Assembly's Snedd building. Other Welsh biomass projects have benefited from the support of Objective 1 funding from the European Union; these include the Wood Energy Business Scheme, the Western Log biomass power station and the Bluestone CHP plant that uses wood and energy-crop biomass.

1.15 The proposed Biomass Energy Strategy will also take account of initiatives, such as an Alternative Fuels Action Plan, to reduce carbon dioxide emissions from transport in Wales. At the same time, the Assembly Government is expected to develop policies which will have an impact on other aspects of biomass production and use, such as the review of land management schemes under the new Rural Development Plan for Wales which will consider the feasibility, cost and benefits of introducing planting grants for energy crops.

1.16 The Working Papers which are being published alongside this strategy give references for the reviews and reports which have informed the strategy.

1.17 Key representatives of the biomass sectors have played an important role in developing this first UK Biomass Strategy through correspondence, face-to-face meetings and the work of the Biomass Implementation Advisory Group (BIAG) and the Renewables Advisory Board. We are grateful to all those who have contributed to this process.

14 http://www.scotland.gov.uk/Publications/2007/03/12095912/0

2. Why Biomass?

2.1 Biomass is an important tool for tackling climate change, as well as offering new commercial opportunities. For the purposes of this Strategy, we are taking biomass to mean any biological material, derived from plant or animal matter, which can be used for producing heat and/or power, fuels including transport fuels, or as a substitute for fossil fuel-based materials and products.

2.2 Figure 1 below identifies the principal plant-based biomass resources typically used for energy and/or as renewable raw materials in the UK. It also identifies the key elements in the supply chain and the processes used to convert biomass into fuel or other renewable raw material. The specific supply system and conversion process that will apply will vary according to the type of biomass involved and the nature of the end use.

2.3 Biomass is renewable and generally has low carbon characteristics. It is theoretically a carbon-neutral fuel – the carbon emissions from the use of biomass as a fuel can be offset by the carbon captured during its growth. However, this balance is sensitive to the carbon intensity used in the production, supply and transport of biomass. Where biomass is produced and processed with due regard to sustainability and carbon savings, it can deliver a reduction in overall carbon emissions and will help tackle climate change. We are keenly aware of the risks of unsustainable production of biomass fuels which can apply both to indigenous production of biomass as well as imported materials, and of the potential air quality impacts of combustion based bioenergy production.

2.4 Biomass is very versatile. It can be used as fuel across the energy spectrum for electricity, heat and transport as well as the production of industrial material. At current usage levels biomass can be considered as an untapped resource. There is scope to extend sustainable production significantly. There is also scope to convert the energy potential of biomass more efficiently through more sophisticated processes such as conversion of woody and other cellulosic material to liquid fuel. Both the Government and the private sector are investing

Figure 1 – Biomass supply chain

Biomass Resources	Supply Systems	Conversion	End Use
Conventional forestry	Harvesting	Biochemical	Transportation fuels
Short rotation forestry	Collection	Thermochemical	Heat
Sawmill conversion products	Handling	Physical/ Chemical processes e.g.	Electricity
Agricultural crops and residues	Delivery	Deoxygenation	Solid fuels
Oil-bearing plants	Storage	Deploymerisation	Renewable construction materials
Animal Products		Pyrolysis	Plant based pharmaceuticals
Municipal solid waste		Gasification	Renewable chemicals including polymers
Industrial waste		Hydrolysis	
		Fermentation	

strongly in research and development into more efficient conversion processes.

2.5 The use of biomass and other renewables, in place of fossil based fuels, offers the prospect of a more diversified energy mix, elements of which could be sourced from most countries across the world. Energy security continues to be of increasing importance. Security of supply requires that we have good access to available fuel supplies from financially robust suppliers, the infrastructure in place to transport them to centres of demand and effective markets so that supply meets demand in the most efficient way.[15] At present 90% of the UK's energy needs are met by fossil fuels and these are expected to be the predominant source of energy for years to come. As UK production of oil, gas and coal declines, we are increasingly reliant on imports.

2.6 Agriculture, forestry and related industries have an important role to play in the way biomass is used to tackle climate change and the environmental challenges we face. Increased biomass use will involve some changes to the way land is currently used and the exploitation of existing technologies such as anaerobic digestion to optimise the use of biomass. Reforms to the Common Agricultural Policy are already encouraging this approach. Properly planned and managed these changes will have a number of environmental benefits and will improve wildlife habitats. We also need to make optimum use of plants and other biological resources by linking bioscience with commercial development to deliver the outcomes we need for industry, society and the environment.

2.7 Biomass energy can also be recovered from waste. Potential sources include biomass wastes such as food and wood together with mixed waste streams which have a biomass fraction e.g. waste derived fuels or residual post recycling waste. Greater use of these biomass sources will reduce dependence on landfill and associated greenhouse gas emissions.

2.8 Biomass is also an important source of renewable materials and products. It can replace fossil fuel based products and materials in a variety of applications from packaging to building materials. The use of biomass in the automotive industry is being developed as is the use of biomass in the pharmaceutical and chemicals industries. Development of biomass use in these areas will be an important element in the move towards a bioeconomy.

2.9 In promoting the use of biomass we are aware that concerns are being voiced about the impact this policy will have on the environment, food supplies and developing countries. We acknowledge those concerns. We will seek to ensure that implementation of this strategy does not lead to increased deforestation and to ensure biomass production does not reduce the production of essential developing countries' food supplies. Consequently this strategy promotes a sustainable and environmentally responsible approach to the expansion of biomass use. A key element in the development of a sustainable Biomass Strategy will be the development of second generation biofuels. For this reason longer term targets for the increased penetration of biofuels are contingent on this.

15 http://www.dti.gov.uk/files/file31890.pdf – Energy Review, page 18, para 4.

3. Biomass strategy

3.1 The Government's strategy for biomass is intended to:

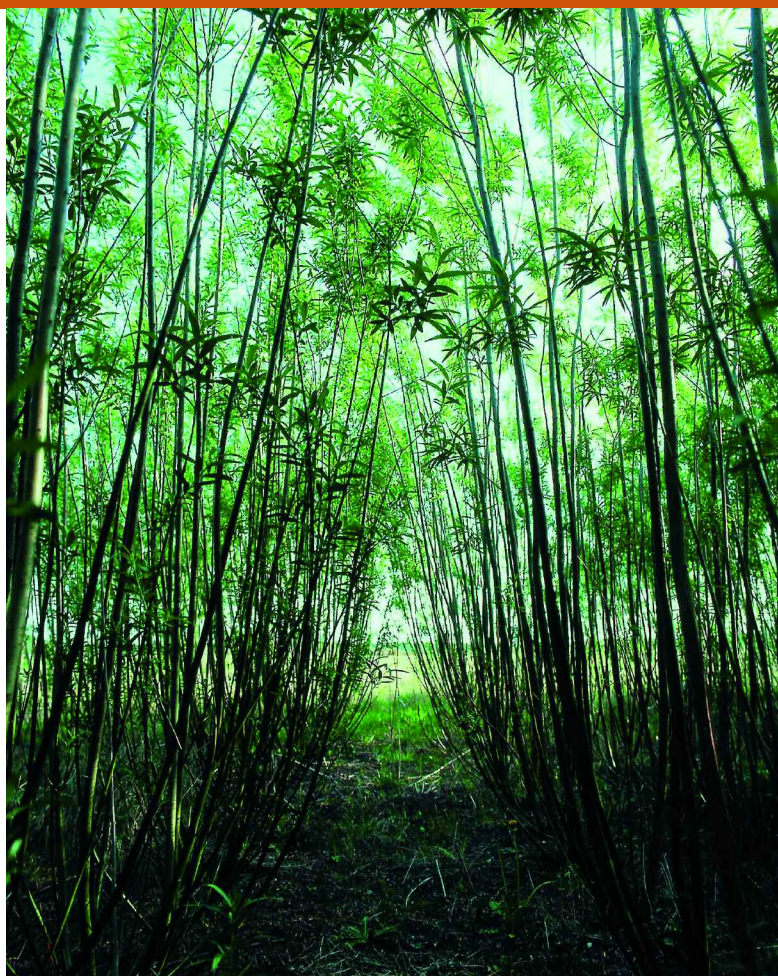
- realise a major expansion in the supply and use of biomass in the UK
- facilitate the development of a competitive and sustainable market and supply chain
- promote innovation and low-carbon technology development so biomass can deliver relatively higher energy yields
- contribute to overall environmental benefits and the health of ecosystems through the achievement of multiple benefits from land use
- facilitate a shift towards a bio-economy through sustainable growth and development of biomass use
- maximise the potential of biomass to contribute to the delivery of our climate change and energy policy goals: to reduce CO_2 and other greenhouse emissions, and achieve a secure, competitive and affordable supply of fuel

3.2 In developing the strategy to deliver these objectives we have looked at the use of biomass across the different energy and renewable materials sectors to identify:

- where biomass can most cost-effectively contribute to decarbonising energy supply
- how biomass can best be used to help meet the UK's renewable energy targets
- the way biomass can be used to develop renewable materials and products e.g. plant based pharmaceuticals, renewable construction materials and renewable chemicals
- how biomass can help deliver low carbon transport

Biomass supply

3.3 Delivery of our objectives will require a major expansion of biomass use for fuel, energy and industrial products. We have looked carefully at the supply side and believe there is significant potential to expand the UK supply of biomass including forestry material, agricultural crops, suitable organic materials such as manures and slurries, certain source separated organic wastes (such as food and wood) and waste derived Solid Recovered Fuels (SRF). We see a



significant role for imports, especially for transport fuels, but we are keenly aware of the environmental risks from unsustainable production and damaging changes of land use. Consequently we fully support the EU approach of linking potential increases in biofuel targets to sustainability criteria. Section 4 looks at biomass supply issues in more detail.

3.4 To help secure a sustainable increase in UK biomass production we will:

- source an additional 1 million dry tonnes[16] of wood per annum from currently unmanaged woodland in England through the implementation of the England Woodfuel Strategy.[17] Expanding the total area of woodland and bringing under-managed woodland back into management will also improve local biodiversity.
- seek to increase the amount of perennial energy crops produced in those parts of the UK where it makes sense to do so, with the potential to use up to 350,000 hectares across the UK by 2020.

16 2 million green tonnes
17 http://www.forestry.gov.uk/england-woodfuel

To help realise this we intend to continue to support energy crop plantings through Rural Development Programmes as well as the current EU Energy Aid Payment, and incentivise their use through the proposed banding of the Renewables Obligation.

- increase the recovery of wood for energy from managed woodlands by promoting the harvesting of forestry residues for energy.
- encourage greater separate collection of wastes such as food and wood for energy recovery[18] and increase the proportion of renewable electricity[19] and heat from waste biomass in England.
- drive a faster growth in the use of anaerobic digestion (AD) by local authorities, businesses and farmers. AD technology has significant potential to contribute to our climate change and wider environmental objectives, as well as delivering biogas for biomass heat and/or power or transport fuel. We want to stimulate and develop the markets for AD and its products, and address the administrative and technical challenges which may hamper its development. To support this aim we will look at how and whether economic or fiscal instruments can facilitate increased use of AD. This includes the potential contribution of Renewable Obligation Certificates (ROCs). We will support the development of the market for digestate and in England, will work through the Environment Agency and WRAP, to develop a standard and protocol for digestate by Spring 2008. We will work with stakeholders to develop and disseminate information on best practice and technology in England, for example through Defra's New Technologies Demonstrator Programme and advice to farmers. We will also continue to work through the Methane to International Methane to Markets Partnership and the International Energy Agency (IEA), Bioenergy Task on Energy from Biogas and Landfill Gas[20] to drive forward thinking about the role of AD internationally and to learn from the experience of other countries.
- continue to promote measures to divert waste from landfill to more sustainable management routes, including increased energy generation from biodegradable wastes that cannot be sustainably re-used or recycled and from SRF.
- encourage local planning authorities to put in place policies to promote and encourage the development of renewable energy resources (which includes energy from biomass) through the planning system.[21] We expect all local planning authorities to include such policies in their plans. The draft Planning Policy Statement on Climate Change, published for consultation in December 2006, expands on that policy, making it clear that local authorities should assess their area's potential for accommodating low carbon and renewable technologies in new residential, commercial and industrial development.
- ensure biomass must be evaluated for all school buildings within the DfES Building Schools for the Future (BSF) programme. The DfES capital programme, will replace or refurbish all secondary schools in England over the next 15 years. During 2007, it will become a requirement that biomass boilers are installed wherever appropriate in new school buildings and refurbishments. This programme will involve almost 4,000 secondary schools over the next 15 years. If it is assumed that biomass is applicable to 25% of schools, then this will result in a reduction in carbon dioxide emissions of around 0.3Mt per annum. A similar requirement will apply to a planned programme for primary schools, whereby 50% of primary schools (approximately 10,000 in number) will be remodelled or rebuilt over a similar 15 year period, with an opportunity to reduce carbon dioxide emissions by a further 0.1-0.2Mt.

3.5 To complement these measures we will:

- take action both to encourage the expansion of biomass production and use across the UK through adjustments to the legislation, where appropriate and possible whilst upholding necessary legislative safeguards.
- promote sustainable biomass production and use actively through specialist information centres, such as the Biomass Energy Centre, the National Non-Food Crops Centre, and organisations such as the Energy Saving Trust and the Carbon Trust.
- integrate policy development by merging policy development flowing from the Biomass Strategy and the Non-Food Crops Strategy into a single integrated renewables programme.
- deliver our policies and aspirations through close working with regional bodies, local community groups and individual entrepreneurs, such as the Regional Development Agencies.

18 7.5 million tonnes of waste wood are produced each year, the majority of which goes to landfill.

19 waste biomass accounted for 6% of renewable electricity generated in 2005

20 http://www.iea-biogas.net/

21 Current planning policy for England is set out in the Planning Policy Statement on Renewable Energy, PPS 22 http://www.communities.gov.uk/index.asp?id=1143908

3.6 A number of measures will be employed to promote the use of biomass generally with end-use sectoral measures described in later sections. General measures include:

- expanding our use of biomass on the Government Estate. In England, we will continue to promote the use of biomass on the Government Estate, through mapping the estate's suitability for biomass boiler use and fuel supply issues. This will involve carrying out feasibility studies and installing biomass boilers on appropriate sites. We will also actively consider using renewable construction materials produced from biomass in the building of new developments on the Government Estate, as a means of reducing their carbon footprints.
- carrying out research and development to help underpin the emerging biomass industries and, through appropriate selection, use demonstration sites to promote best use of biomass. e.g. the Technology Programme support for R&D into the development of second generation biofuels and biorefineries for the more efficient use of biomass. We see the use of biomass for energy and industry within a wider framework of moving to a bio-economy in which the bio refinery approach[22] will increasingly be adopted.
- addressing technical barriers to accreditation under the Renewables Obligation for eligible waste to energy schemes e.g. to enable the biomass energy content of the biomass fraction in mixed wastes to be determined in accordance with legislative requirement and to allow non-waste biomass to be co-fired with Solid Recovered Fuel (SRF) without losing its ROC eligibility.
- supporting development of energy markets for waste wood and waste derived fuels through the Waste Implementation Programme, including through extension of the Enhanced Capital Allowance scheme for good quality CHP to support combustion of SRF.

Biomass for energy

3.7 By taking measures to support the use of biomass for energy we will increase demand for biomass, stimulating an increased supply. A range of support measures are already in place including grants to support the development of the under-pinning technologies and incentives to promote the use of biomass to generate electricity and heat.

3.8 We have considered how far these different incentives support the cost-effective use of biomass to reduce carbon emissions from energy. The conclusion from our analysis is that heat applications (generally medium to large sized installations) represent the most cost-effective way of exploiting the carbon reduction potential of biomass, followed by combined heat and power (CHP) for industrial intensive energy users, biomass co-firing with coal in electricity generation, other forms of electricity generation from biomass alone, and transport fuels. This is a broad classification based on indicative data and there will be specific cases that go against this overall pattern e.g. district heating is highly site specific and costs can vary considerably. The results are sensitive to biomass and future fossil fuel prices, the scale and utilisation of the energy generation plant and the nature and level of processing applied to the biomass.

Electricity

3.9 The Renewables Obligation is our main policy measure for stimulating the growth in electricity generation from renewable sources and for achieving our target of 10% of electricity from renewable sources by 2010 and our aspiration to reach 20% by 2020. Biomass has an important role to play in achieving these targets, both through co-firing and the use of dedicated biomass. In recognition of this we will:

- consider changes to the Renewables Obligation including banding to provide more targeted support for the use of biomass, for electricity generation. We have today issued a consultation document[23] proposing changes to the Renewables Obligation to provide differentiated levels of support to bring forward a diverse range of renewable power sources (known as banding). The banding levels have been set to recognise the costs of new economic projects in each technology; increase deployment; bring forward emerging renewable technologies and improve the overall cost effectiveness of the Renewables Obligation. We will be asking in the consultation document whether the support offered to the variety of different forms of biomass is appropriate. This includes reducing support for non-energy crop co-firing, maintaining support for energy crop co-firing, and providing additional support to dedicated biomass projects, including a higher level for biomass CHP. The consultation also contains proposals to make the

22 A biorefinery efficiently converts the primary components of cellulose and hemicellulose into fermentable sugars. Lignin, a large and very stable molecule which cannot be converted into sugar, is recovered and used as fuel, providing a significant portion of the energy needs of the process.

23 www.dti.gov.uk/file39497.pdf

Obligation work more effectively for waste biomass, e.g. to remove the disincentive for co-firing non-waste biomass with waste derived fuels, without extending eligibility in this area; and measures to enable the biomass energy content of mixed waste streams to be determined in a cost effective manner.

- continue to work towards achieving at least 10,000 MWe of installed Good Quality CHP[24] capacity by 2010. This target was introduced in 2001 in recognition of the carbon savings CHP can deliver in comparison with conventional forms of power generation. To support the target, we have introduced a number of support measures (section 5.12), such as the eligibility of energy from waste schemes that utilise CHP to claim ROCs on the biomass element of their fuel. A further measure, the target to source at least 15% of electricity for use on the Government Estate from Good Quality CHP by 2010, can also provide opportunities for the use of biomass.[25]

Renewable heat (and cooling)

3.10 Renewable heat, partly but not entirely sourced from biomass, currently accounts for only around 1% of heat supply in the UK. We have supported renewable heat/CHP through a range of capital grant schemes (such as the Bioenergy Capital Grants Scheme and the Low Carbon Buildings Programme). Large renewable heat loads (over 20MWth) benefit from eligibility under the Emissions Trading Scheme. We have also commissioned Ernst & Young to produce a report on the initial business case on support for renewable heat.

3.11 The Government undertakes to do further work on potential measures to support renewable heat, which could reward the carbon savings of this source of heat, secure sustainable investment in this developing sector, and achieve the growth potential that has been identified. This work is part of a wider study to reduce the carbon impact of heat. Further details are set out in Chapter 3 of the Energy White Paper.[26]

3.12 The Government has recently brought into force legislation that will enable us to extend the scope of the Energy Efficiency Commitment (EEC) so that energy suppliers could promote micro generation, including biomass, as part of their activity to meet their targets. The statutory consultation on EEC 2008-11 has commenced.[27]

Transport biofuels

3.13 Biofuels are one of a limited number of ways to reduce emissions from road transport which is currently less able than other energy sectors to use low carbon sources. While transport biofuels currently offer, on average, lower carbon abatement per unit compared to other options, we are keen to encourage the development and use of those renewable transport fuels that offer the highest levels of carbon savings with the minimum adverse environmental impact. Less than 1% of UK road transport fuel is currently sourced from biofuels. Market based measures and road fuel duty reductions are therefore being used to promote the provision of biofuels for transport.

3.14 The UK is already seeking to deliver 5% of transport fuels by volume from biofuels by 2010 through the introduction of the Renewable Transport Fuel Obligation (RTFO) in April 2008. In its consultation document on the RTFO, published on 22 February 2007,[28] we have undertaken to consider increasing the level of the RTFO post 2010 subject to key conditions being met in respect of carbon and sustainability standards, the need to protect existing vehicles from mechanical damage and cost to the consumer. Similar conditions apply to the recent EU Council proposals on EU transport petrol and diesel consumption.

3.15 The agreement reached at the European Council on 8/9 March sets a biofuels target of 10% by energy content by 2020. Implementation is conditional on biofuels being produced sustainably, second generation biofuels becoming commercially available and the Fuel Quality Directive being amended accordingly to allow for adequate levels of blending.

Supply chain

3.16 An efficient and sustainable supply chain is essential if we are to successfully increase biomass use. Reflecting the state of the industry, the biomass supply chain is in the development stage, but measures are either already in place or in progress to address both domestic production of feedstocks and imported biomass supply. Rural Development

24 Broadly, to be fully certified as 'Good Quality', a CHP scheme must have a Quality Index (QI) of 100 and a power efficiency of at least 20%. Further information on CHPQA certification, including the methodology behind the QI calculation, can be found at www.chpqa.com.

25 www.sustainable-development.gov.uk/government/estates/targets/htm

26 www.dti.gov.uk/energy/whitepaper

27 http://defraweb/environment/energy/ccc/index.htm

28 http://www.dft.gov.uk/consultations/open/draftrtfo/rtfo

Programmes are being used domestically to support sustainable establishment of energy crops and development of the woodfuel supply chain for heat and electricity supply as are grant schemes, such as the Bioenergy Infrastructure Scheme in England. The efficient chain that already exists for the supply of materials to the food industry is expected to be used for the supply of transport fuel feedstocks. Feedstocks from both domestic and imported sources for use in electricity generation and transport fuels will be subject to sustainability reporting being developed for the RO and the RTFO.

3.17 Government support for the development of biomass supply is intended to make optimum use of biomass to deliver the outcomes we need for industry, society and the environment. The National Non-Food Crops Centre (NNFCC), established with Government support in 2003, is operating very successfully to promote and develop knowledge and use of plant materials for non-food purposes. The NNFCC is engaged in highly targeted work with industry on potential technology deployment including new-generation biofuels. This role is expected to expand. In 2006 the NNFCC became a partner in the Bioscience for Business Knowledge Transfer Network which brings together the science and industry communities across the whole range of plant, microbial and marine bioscience applications. Bioscience for Business is now pressing ahead with partner organisations and stakeholders to develop integrated science and deployment programmes including the development of an Integrated Biorefining Technologies Initiative in the UK. Defra will increase expenditure on non-food crops from 2008/09. The details will be confirmed in the Comprehensive Spending Review (CSR) later in 2007.

3.18 We are committed to the integration of action to develop biomass supply and the use of renewable energy sources. We are working closely with the Regional Development Agencies (RDAs) on the development of regional carbon targets. The RDAs also have a key role to play in building the partnerships needed to develop supply chains as an integral part of the regional strategies for renewable energy development. This will facilitate the development of supply chains best suited to local needs and resources. We have also provided support for the Community Renewables Initiative which gives advice to local communities on the installation of renewable energy systems. Further information on these activities is available in the Government Response to the Biomass Task Force Report.[29]

Renewable materials and industrial products

3.19 We believe that, in addition to bioenergy, there is significant potential for development of other non-food uses of biomass. We will therefore be seeking to promote sustainable growth in the following three materials sectors:

- plant based pharmaceuticals, nutriceuticals and bio-actives
- renewable construction materials
- renewable chemicals (including oils, monomers and polymers)

Details of the key actions we are pursuing to drive forward developments in each of these priority sectors are set out in the Government response to the 2 year progress report on the Non-Food Crops Strategy[30] published in May 2007. The strategy action plan has been refocused to concentrate on key cross cutting drivers such as:

- communication
- education
- integrating supply chains
- adding value to products
- more focused and joined up R&D
- greater use of public procurement

this should help push forward progress on the four energy and materials priority sectors over the next three years.

Measures to reduce energy use

3.20 While not directly involving the use of biomass we will be adopting a number of measures to reduce overall energy use and carbon emissions. These measures, which will have an impact on projected biomass utilisation, include:

- making all new homes zero carbon by 2016[31] by recognising the strategic importance of building requirements in driving forward reductions in carbon emissions. To achieve this target there will be progressive tightening of the energy efficiency standards in building regulations by 25% by 2010 and by 44% by 2013 – up to the zero carbon target in 2016. From 1 May 2007 the revised environment standards cover the storage of biomass (to limit the risks from fire) and the use of transport deliveries.
- reducing carbon emissions by schools by investing £110 million over the next three years as part of the rebuilding and refurbishing

29 http://www.defra.gov.uk/farm/crops/industrial/energy/biomass-taskforce/index.htm
30 http://www.defra.gov.uk/environment/climatechange/index.htm
31 http://www.communities.gov.uk/index.asp?id=1002882&PressNoticeID=2349 – Speech by Ruth Kelly (SoS, DCLG) on 13 December 2006

secondary schools programme. This will involve the application of higher standards for new and refurbished secondary schools to reduce their carbon emissions, with up to 2,000 secondary schools becoming carbon neutral as a result.

- putting climate change at the heart of the planning system by focussing on reducing the need for travel and making best use of low carbon and renewable energy. This will apply to all developments, not just homes and is reflected in the Planning Policy Statement on Climate Change. This will improve both the energy efficiency of the fabric of homes and the type of energy supplied.
- Introducing a Code for Sustainable Homes. This will contribute to the zero carbon target. New homes will be given a star rating from one to six, with six representing zero carbon and highly sustainable. This should act as an incentive for buyers and developers. The stamp duty exemption for zero carbon homes will act as a further incentive for developers

International

3.21 We recognise that there are many countries in which bioenergy has made a more significant contribution towards energy generation for a variety of reasons and where renewable materials are more widely used. We will continue to engage internationally to establish what lessons we can learn and will continue to play an active role to promote the sustainable use of biomass at an international level. More specifically we:

- are committed to adopting the CEN European Standards for Solid Biofuels and Solid Recovered Fuels in England. We will support the BSI's mirror committee in the development and transition of the standards from Technical Specifications to full European Standards (EN) to ensure they provide useable robust documents for the UK. We will integrate the CEN Standards into Government procurement processes. We are working to make the solid biofuel technical specifications available as a free download through the Biomass Energy Centre website (www.biomassenergycentre.org.uk). Additionally we will support the industry and end users through a series of information documents and events, to ensure the standards are understood and integrated into everyday use.
- will actively engage at EU and international levels with a view to developing targets for sustainable biomass renewable energy use and taking forward the agreements reached at the Spring European Council. We will continue to support the efforts of the UK-Brazil-Southern Africa Biofuels Taskforce in assisting Mozambique to implement a national biofuels strategy and thereafter development of an SADC region biofuel market.
- will actively engage with international bioenergy fora such as the Global Bioenergy Partnership (GBEP), the International Biofuels Forum launched recently (this involves the USA, Brazil, India, China and South Africa, with the UK represented via European Commission) and the International Energy Agency Bioenergy Implementing Agreement. This work seeks to improve co-operation and information exchange between countries with national programmes of research, development and deployment. The agreement aims to accelerate the use of environmentally sound, sustainable and cost effective bioenergy and involves 21 countries plus the EU. We will continue to contribute to the development of global sustainability criteria for biofuels through such bodies.

Skills

3.22 We recognise that a well trained and highly skilled workforce is important to ensure the future success of the biomass industry. Following 9 months of research the Energy and Utility Sector Skills Council (EU Skills)[32] has published draft Stage 1 and Stage 2 Sector Skills Agreement (SSA) Reports. These reports are based on information gathered with the help of employers and stakeholders in the biomass sector. The development of Sector Skills Agreements (SSAs) will provide a structured framework within which all parties can collaborate to create an evidence-based skills need assessment. They will also form a basis for agreement with the Government on how skills needs are to be approached,

Funding

3.23 Defra expenditure on non-food crops will be increased from 2008/2009. The exact details will be determined in the Comprehensive Spending Review (CSR). Funding for Defra's 5-year Bioenergy Capital Grants Scheme and details of the joint DTI/Defra Environmental Transformation Fund(ETF) will also be determined through the CSR.

32 www.euskills.co.uk

4. Biomass supply

4.1 Information on current biomass use and supply is fragmented and as a result more work will be needed to provide a comprehensive overview of the current situation. The Biomass Task Force[33] identified that there were approximately 4.8-5.7Mtoe[34] of biomass resource available for bioenergy production. (This total did not include any estimate of available biomass for liquid biofuel production.) A recent update of this assessment (Annex A) of current availability has suggested a slight increase in biomass, to between 5.6-6.7 Mtoe.[35/36] Imports of biomass, biofuels and biofuel feedstocks play an important role in meeting current UK demand and will continue to do so. The map at Annex G shows current and planned production and storage installations for biofuel and biomass.

Table 1 – Current levels of bioenergy production and use

	Quantity	Year	Million tonnes of oil equivalent (Mtoe)[37]	Percentage of UK total[38]
Bioenergy use				
Bioethanol	85 million litres (95 million litres)	2005 (2006)	0.04 (0.05) [39]	0.2% (0.2%) of total transport fuel sales
Biodiesel	33 million litres (169 million litres)	2005 (2006)	0.03 (0.14) [37]	0.1% (0.3%) of total transport fuel sales
Bioenergy generation				
Electricity	3.1 Mtoe[40]	2005	3.1	3.5% of UK electricity production
Heat	0.45 Mtoe[41]	2005	0.45	0.6% of heat generation

33 http://www.defra.gov.uk/farm/crops/industrial/energy/biomass-taskforce/pdf/btf-final-execsumm.pdf – Appendix D, 2005
34 Equivalent to 201,838 TJ of energy.
35 Annex A
36 mainly due to an increased availability of waste wood and revised calorific values
37 http://data.iea.org/ieastore/Assets/products/BLUE/Blucon.pdf
38 Biofuels calculated on a volumetric basis, as a percentage of total diesel and petrol releases (data from UK Trade Info/HMRC). Excludes gas for road fuel (LPG) which accounted for 0.5% of sales in 2006.
39 Energy density of bioethanol = 26.7Gj/tonne (21.1 MJ/l), Energy density of biodiesel = 40.128GJ/tonne (35.3 MJ/l) (from International Resource Costs of Biodiesel and Bioethanol, AEA Technology for DfT 2003).
40 Digest of UK Energy Statistics (DUKES) 2006, URN No. 06/87, Table 7.7 & 7.4.
41 DUKES 2006, URN No. 06/87, Table 7.7.

Bio energy use

4.2 Current (2005 with 2006 figures where available in brackets) levels of bioenergy production or use are outlined in Table 1 below.[42/43] Production of crops for industrial materials and products has been reported as totalling 319,000 tonnes in 2005.[44/45]

4.3 To put the biofuels figures in Table 1 into context, the introduction of the RTFO will require approximately 0.68Mtoe of bioethanol and 1.1Mtoe of biodiesel to be used in the UK by 2010.

4.4 The potential carbon savings arising from the use of existing biomass resources for energy generation are shown at Annex B. Annex C considers the UK biomass resource that could be technically available (i.e. neglecting financial and market constraints and excluding biofuel crop production). On this basis the estimated size of the potential future biomass resource in the UK is approximately 96.2 TWh (8.3 Mtoe).[46] If it is assumed UK biofuel crop production can supply half of the 5% (by volume) target for 2010,[47] this gives a total predicted theoretical biomass resource level in the UK of around 10.0 Mtoe[48] (rising potentially to 14.1 Mtoe if second generation biofuel technology becomes available and it is assumed that UK biofuel crop production can deliver half of the 10% (by energy) EU target for 2020).[49]

Figure 2 – Future environmentally-compatible bioenergy potential (in MtOE) in the United Kingdom

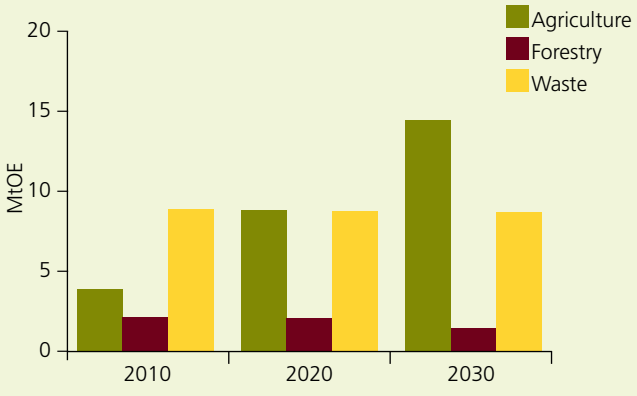


Table 2 – Amount of biomass needed to supply 1% of primary energy requirements for the heat, electricity, and transport fuels sectors

Sector	UK primary energy requirements per year (Mtoe)[51]	Amount of biomass needed to supply 1% of primary energy requirements (Mtoe)
Heat	79.78[52]	0.8
Electricity	85.0[53]	0.9
Transport fuels	42.4[54]	0.4
Total:	207.18[55]	

4.5 These estimates could be considered conservative. The European Environment Agency (EEA) recently estimated the environmentally compatible energy potential of the UK to be 13.5 Mtoe in 2010, 19.0 Mtoe in 2020 and 24.5 Mtoe in 2030 (these figures assume lower levels of waste recycling and composting than those used at Annex C). Figure 2[50] below shows the future environmentally compatible bioenergy potential in the UK based on the EEA's analysis.

4.6 To set these estimates in context, Table 2 indicates how much biomass is needed to supply 1% of primary energy requirements for the heat, electricity, and transport fuels sourced from biomass. However, imports will (as discussed below) have a role to play in delivering future UK bioenergy supply requirements.

4.7 Increases in biomass availability will be achieved through the more efficient utilisation of agricultural land, wood fuels, unmanaged woodland, manures and slurries, and certain organic wastes. This could include expanding production of biofuel and energy crops on agricultural land and the development of new woodland.

42 Based on 2005 data.
43 Data for use of biomass for industrial (non-energy) uses are not currently available.
44 Reported in: 'A strategy for non-food crops and uses – two year progress report: Table 1 – excluding energy use http://www.defra.gov.uk/farm/crops/industrial/pdf/nfc-progress-0611.pdf
45 It is not possible to provide an equivalent Mtoe value because detailed information is not available on the types of crops comprising the 319,000 tonnes and the respective calorific values of the plant products used.
46 This total excludes any value for biomass for liquid biofuel production (i.e. from oilseed rape, wheat or sugar beet).
47 Based on the amount of biofuel feedstocks needed to supply 50% of the 5% (by volume) RTFO target, with a 55:45 split between biodiesel and bioethanol.
48 These assessments do not take into account the biofuel production that could be sourced from waste oils which currently are disposed of in landfill or additional straw produced with first generation biofuel feedstocks.
49 Based on the additional amount of biofuel feedstock required to meet 50% of the 10% target through second generation processes.
50 Based on the *EEA Report* – How much bioenergy can Europe produce without harming the environment? No 7, (2006), ISSN 1725-9177.
51 Base year: 2005 (Digest of United Kingdom Energy Statistics (DUKES) 2006, URN No. 06/87, Table 1.1).
52 Primary energy for heat excluding electricity for heat and energy for cooking/catering (DTI statistics – unpublished).
53 Primary energy for heating is included in the electricity total (DUKES 2006, URN No. 06/87, Table 1.1).
54 Based on final road transport consumption data (DUKES 2006, URN No. 06/87, Table 1.1).
55 Excludes non-energy use of fuels (12.6 Mtoe), final consumption of oil for air, rail and national navigation (16.1 Mtoe) and other primary energy uses not included in the three categories such as mechanical power, use by the energy industries and other transformation and distribution losses (17.8 Mtoe).

Table 3 – Feedstock for co-firing by type, quantity and source

Feedstock	Quantity burned (tonnes) in 2005	% quantity burned (tonnes) in 2005	Likely country of origin	Mode of transport	Total transport-related emissions (kg CO_2/tonne biomass)
Energy crops (SRC,granulated willow, miscanthus)	4,306	0.3	UK	Road	1.7
Shea residues (meal and pellets)	5,420	0.4	Africa	Ship	55.4
Sunflower pellets	20,331	1.4	Romania	Road & ship	47.1
Sewage sludge and waste derived fuels	49,155	3.5	UK	Road	3.4
Cereal co products and pellets	102,246	7.2	UK	Road	1.7
Tallow	119,828	8.5	UK	Road	1.7
Olive waste (residue and expeller)	283,222	20.1	Greece, Italy Spain	Road & ship	21.2
Wood (sawdust, chips, pellets, tall oil)	377,956	26.8	UK, Canada, Latvia, Scandinavia	Road & ship	1.7 (UK) to 42.9
Palm residues (palm kernel expeller, shell, pellets, oil)	449,657	31.8	Indonesia, Malaysia	Road & ship	106.5 (Indonesia) to 107.4 (Malaysia)
Total mass	1,412,121				
Total energy (PJ)	14.1				

Source: Evaluating the Sustainability of Co-firing in the UK, report to DTI from Themba Technology Ltd, September 2006.

4.8 The Woodfuel Strategy[56] for England seeks to bring an additional 1m tonnes (2m green tonnes) of wood to market annually by 2020. This represents some 50% of the unharvested available material in English woodlands. The Woodfuel Strategy recommends a combination of capital investment and support, outreach and facilitation and awareness raising to secure this increase. This will bring more woods into productive and sustainable management. The Woodfuel Strategy also acknowledges the need to make the currently fragile wood fuel supply chain more robust.

4.9 We will establish a policy framework which is highly encouraging to the deployment of biomass, including the greater use of anaerobic digestion and wood, and will encourage technology development to deliver innovation in the most sustainable uses of biomass.

Imports

4.10 The UK currently imports significant amounts of biomass material for bioenergy applications. Precise data are difficult to obtain, but it is estimated that in 2005 Great Britain imported a minimum of around 0.76[57] million tonnes of biomass for co-firing for electricity production (at least 54% of the total 1.4 million tonnes of biomass co-fired).[58/59] The materials in question consisted largely of palm oil residues, olive residues, sunflower pellets and shea meal, from Indonesia, Southern Europe and Africa, as outlined in Table 3.

4.11 The majority of the bioethanol used in the UK for transport biofuels over the past few years[60] has been imported in finished form, mainly from Brazil where home consumption is rising. In contrast, with biodiesel the feedstocks rather than the finished product are imported into the UK. Palm oil is sourced from Indonesia and Malaysia, soya oil from North and South America, while oilseed rape is traded in Europe. Imports of these products have increased by some 76% since 2004 and it is estimated that much of this increase was used to produce biodiesel (as opposed to food use). We expect that biofuel imports will play an important role in meeting the RTFO targets.

4.12 We also expect that biomass imports will continue to be a significant source of biomass feedstocks for co-firing. However, the specific level of imports will depend on international competition for biomass and the relative availability (and price) of indigenous feedstocks. We anticipate that imports will

56 http://www.forestry.gov.uk/england-woodfuel
57 This figure excludes dedicated biomass for electricity production
58 http://www.dti.gov.uk/files/file34448.pdf
59 Evaluating the Sustainability of Co-firing in the UK, report to DTI from Themba Technology Ltd, September 2006.
60 95 million litres of bioethanol were consumed in the UK in 2006

also play a part in the development and expansion of the biomass heat sector. However, local sourcing of feedstocks will better suit some applications.

Domestic supply

4.13 The UK has a number of renewable energy targets to meet. This will require a major expansion in current domestic biomass production and supply. The European Environment Agency (EEA)[61] recently assessed the amount of biomass that could technically be available for energy production in each Member State without increasing pressures on the environment. This report concludes that in the short term the largest potential for bioenergy comes from the waste sector. In the longer term, bioenergy crops from agriculture are considered to offer the largest potential with seven Member States (Spain, France, Germany, Italy, the UK, Lithuania and Poland) contributing about 85% of the increase forecast. The EEA[62] report has concluded that the land available for environmentally compatible potential bioenergy production in the UK will be around 0.8m hectares in 2010, 1.1m hectares in 2020 and 1.6m hectares in 2030. It is essential that we ensure any significant expansion in the use of land for bioenergy production is sustainable. The EEA study offers some guidance on this process.

4.14 Previous research under the Renewables Innovation Review (2004)[63] estimated that 350,000 hectares of land in the UK is suitable for the production of energy crops, once a number of constraints, including competition from other markets, are considered. More recently, work has been undertaken by Natural England, Defra, the Regional Development Agencies and the Environment Agency to map in greater detail the suitability of land across England for energy crops.[64] A range of environmental factors were overlaid on existing maps and matched to the crops' requirements to produce a series of regional maps which indicate those areas of land which are suitable for the individual biomass crop types. These maps[65] provide a useful tool for those planning, or assessing, biomass-based developments. A similar project has been undertaken by the Welsh Assembly Government, with the development of a GIS map which demonstrates suitable land for growing SRC and energy grasses. The information is based on soil type, the maximum height above sea level that the crops can feasibly grow and excludes land such as nature conservation sites.

4.15 If we assume half the RTFO target of sourcing 5% (by volume) of transport fuels from biofuels by 2010 is to be met from UK-produced arable crops, approximately 740,000 hectares of land would be required[66] (see Table 4).

4.16 This land requirement of around 740,000 hectares for biofuels when considered with potential energy crop coverage by 2010, is expected to be close to the 800,000 hectares identified by the EEA. However, to ensure compatibility with our environmental objectives we must ensure that these crops are sustainably sited and managed.

4.17 It is likely that by 2020 second generation biofuel technologies will be in place. This should make the production of biofuels from land much more efficient, with a reduced area needed to produce a given volume of biofuels. However, with the prospect of an increased target for biofuel use (above the current RTFO target of 5% by volume)

Table 4 – UK Land Requirements[67] to meet the RTFO target assuming 50% imports of biofuels

UK	Crop Type	Total biofuel demand[68]	Amount of UK crop required[69]	Amount of UK land required[70]
		Mtoe	tonnes	hectares
5% RTFO by volume				
Bioethanol	Wheat	0.34	1,715,000	214,375
Biodiesel	Oilseed	0.55	1,680,750	525,234
1% increase				
Bioethanol	Wheat	0.07	343,000	42,875
Biodiesel	Oilseed	0.11	336,150	105,047

61 http://reports.eea.europa.eu/eea_report_2006_7/en
62 http://reports.eea.europa.eu/eea_report_2006_7/en
63 Renewables Innovation Review http://www.dti.gov.uk/files/file22017.pdf DTI/Carbon Trust 2004
64 Short rotation coppice and miscanthus
65 http://www.defra.gov.uk/farm/crops/industrial/energy/opportunities/index.htm
66 Using UK yield data from Agriculture in the United Kingdom (2006) and 60:40 use of biodiesel : bioethanol
67 Based on the findings of the EEA Report EEA (2006) "How much bioenergy can Europe produce without harming the environment?" (EEA no. 7/2006) http://reports.eea.europa.eu/eea_report_2006_7/en
68 Estimated fuel consumption taken from Turley (2005), An Assessment of the Potential Environmental Impacts Arising From Cultivation of Wheat and Oilseed Rape For Liquid Biofuel Production, Central Science Laboratory
69 Conversion coefficients taken from Smeets, Junginger and Faaij (2005), Supportive study for the OECD on the alternative developments in biofuel production across the world, Consultancy report for the OECD Secretariat
70 Yields taken from Agriculture in the United Kingdom 2005

and further expansion in the production and use of energy crops for bioenergy, overall land requirements for bioenergy production are expected to increase by 2020. In the current situation, where second generation technologies are not available, precise calculations cannot be made. We currently expect arable land use for bioenergy production will continue to increase and that it will be close to the EEA estimates of land available in the UK (1.1m hectares in 2020).

4.18 At the same time we also envisage further expansion in the use of crops for industrial applications. Current production in England, for example, is of the order of 115,000 hectares.[71/72] Land use demands for the different crops vary considerably. Novel or more specialised crops e.g. for pharmaceutical uses, are currently grown in quite small volumes, while oilseed rape for industrial uses accounted for over 50,000 ha in 2005. Increasingly, part of a crop may be used for food while co-products are used as industrial raw materials or fuel, utilising a biorefinery approach. In practical terms, the target of achieving 0.1 million tonnes of carbon savings from industrial uses of crops, as detailed in the UK Climate Change Programme Review (CCPR),[73] could therefore be met through a number of approaches. Markets are developing and, through the work of organisations such as the National Non-Food Crops Centre (NNFCC), we are seeing increasing interest in this potentially high value sector.

Agriculture and land use

4.19 While individual decisions on changes of agricultural land use will need to pass the test of sustainability and the provision of multiple environmental benefits, we believe that a significant expansion of UK biomass production and use is realistic and achievable. This underpins the overall ambition of this Biomass Strategy and is consistent with our wish to see an enhanced, sustainable approach to land-use meeting the environmental challenges we face.

4.20 Reform of the Common Agricultural Policy is seeking to establish an agricultural industry which is:

- internationally competitive without the need for subsidies or protection
- rewarded by the market for its outputs with support by the taxpayer limited to the delivery of social benefits the market cannot deliver
- environmentally sensitive, while maintaining and enhancing the landscape and tackling pollution
- socially responsive to the needs of rural communities
- producing to high levels of animal health and welfare
- not distorting international trade and the world economy

These reforms, together with the vision for a confident, diverse and sustainable UK farming industry, are encouraging an innovative, market-led industry which contributes positively to the environment. Agriculture, together with forestry and associated industries, has a key role to play in tackling climate change. We have set out[74] the specific contributions which the land-based industries can make in reducing emissions and growing crops for fuel, energy and industrial materials. Many of the opportunities, such as anaerobic digestion, are currently under-developed and the measures set out in this strategy will help the industry to move forward to optimise the potential.

Competition for land

4.21 Concerns have been raised about the potential for increased biomass production, particularly arising from the planned introduction of the RTFO, to impact negatively on the availability of land and on existing markets through rising commodity prices, as food and non-food markets compete for the same crops. This strategy seeks to ensure that competition for land will not constrain the achievement of our renewables and biofuels targets by also recognising and encouraging the role that non-agricultural land based biofuels sources, such as wastes and wood can play.

4.22 We will monitor the impact of this strategy on the biomass/food balance. In the longer term, with Europe and the wider world looking to diversify their fuel supplies further, competition for the available bioenergy feedstocks is likely to increase, which could increase the price of biomass for fuel. Global demand for biofuels is already having an impact on food markets[75] and will be a significant factor in future decisions on the level of biofuel targets. Again data on food price impacts are fragmented. A recent EU working document[76] considers the impact of increased biofuel demand on food commodity prices. It suggests that overall any adverse impact is expected to be limited. However, the working document does

71 A strategy for non-food crops and uses – two year progress report: Table 1 – excluding energy use http://www.defra.gov.uk/farm/crops/industrial/pdf/nfc-progress-0611.pdf

72 Growing area details for some non-food crops are not declared and this may therefore give an underestimate.

73 http://www.defra.gov.uk/environment/climatechange/uk/ukccp/review04/index.htm

74 Climate Change Programme 2006

75 http://www.publications.parliament.uk/pa/cm200607/cmselect/cmenvfru/131/13102.htm

76 www.ec.europa.eu/energy/energy_policy/doc/07_biofuels_progress_report_en.pdf

acknowledge that increased demand for biofuels will have a negative effect on other industries that use the same raw materials. Here it suggests that parts of the food industry, chemical industry and forest based industries are most likely to be affected. However, the scale is not expected to be significant and users of biofuel by-products can expect cost reductions.

4.23 As previously acknowledged second generation biofuels are expected to require less land to deliver the same amount of biofuel, and will continue to be an important area for policy development. There are also prospects for developing novel sources of biomass such as marine algae and European research programmes are taking a keen interest in this area. These will be key considerations in determining the balance between home produced and imported biomass and the level of biofuel imports needed to achieve the EU renewables and biofuels targets.

Environmental impacts

4.24 Increasing the supply and use of biomass has implications for land use, biodiversity and other environmental factors and landscape. If properly planned, biomass development, in addition to helping climate change objectives, may have positive environmental effects, consistent with enhancing the overall health of ecosystems. For example, increasing woodfuel supply from previously unmanaged woodlands can improve wildlife habitat, preserve the historic and cultural value of certain woodlands, provide a landscape asset, improve access to some woodlands and potentially contribute to the rural economy.

4.25 A four year DTI study carried out by the Game Conservancy,[77] in collaboration with the Central Science Laboratory in York, monitored the biodiversity of commercially grown short rotation coppice (SRC) willow. The study found that SRC can benefit some of the Government's Public Service Agreement target farmland bird species, including skylarks and lapwing. Higher densities of birds were recorded during summer in the SRC than in the arable fields. In winter, there were on average more species of birds in the SRC plots compared to the arable crops. Butterflies and invertebrates were also studied. The less mobile species of butterfly, such as the Skippers and Browns, that require long grasses to complete their lifecycle, were especially attracted to the SRC headlands.

4.26 Replacing arable crops with certain perennial energy crops can, if properly managed, lead to gains in biodiversity. Generating energy from manures and slurries and certain organic wastes through anaerobic digestion can help to mitigate methane emissions from agriculture and to divert organic waste from landfill, as well as providing renewable energy. Other environmental benefits, when anaerobic digestion is operated well and the digestate applied correctly to land, include improved air and water quality. These changes, while providing economic returns from the business activities, will contribute to the delivery of multiple benefits which we see as becoming increasingly important as we seek to optimise the use of our limited land resource.

4.27 A number of important environmental functions are performed by forests, especially forest residues and deadwood (many species depend on deadwood, particularly of large diameters). Forest residues provide a source of nutrients; regulating water in soils; and helping to prevent soil erosion, as well as providing habitats. Biomass removal from forests, whether for timber production or energy, must be done in a way that minimises adverse impacts on these functions. By applying the principles of Sustainable Forest Management,[78] favourable conditions can be created for maintaining biodiversity and the share of deadwood can be increased. Positive impacts resulting from biomass removal may include the lowering of nutrient leakage on eutrophicated sites and rejuvenilation of declining woodland, opportunities for light demanding species (including ground flora and associated flora, as well as trees) when heavily shading canopies (e.g. dense coniferous forest plantations) are opened, and removal of exotic and invasive species.

4.28 At the same time we fully recognise concerns over potential adverse impacts from increasing production of biomass both domestically and globally. The Stern Review[79] highlights the devastating effect of deforestation in releasing carbon, as well as destroying valuable ecosystems. In promoting the increased use of biomass we will seek to ensure holistic management of ecosystems and the adoption of sustainable practices, for example through the appropriate siting and management of energy crop plantations.

4.29 Some biomass crops can benefit the soil by adding organic matter and resisting erosion through the binding effect of dense root systems and providing a good cover of the soil surface. However, biomass crops also have the potential to damage the soil during their establishment, harvesting and removal. Bringing new land, particularly permanent grassland, into arable production could result in large losses of soil carbon, removing the carbon

77 www.dti.gov.uk/files/file14870.pdf
78 MCPFE, 2006, see MCPFE website http://www.mcpfe.org/
79 http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

benefits of the biomass production and is to be avoided where this would be the case. It could also increase the risk of nitrate leaching. Other risks to soil from some crops include structural damage (compaction) during harvesting and soil erosion from bare or compacted soil (including loss of soil carbon in particulate form). Additionally, the high water demand of some crops can lead to the drying out of the soil with subsequent oxidation and losses of soil carbon and an increased risk of erosion and, potentially, a reduction in the amount of recharge of any underlying groundwater aquifers. Careful consideration of the placement and management of crops to reduce these risks is a requirement of the proposed EU Soil Framework Directive.

Impact of climate change

4.30 Some environmental factors, resulting from climate change, are expected to impact severely on our ability to grow certain types of biomass across the UK in future years. Annex D shows the current distribution of forest types. While increased carbon dioxide levels may act to promote photosynthesis and increase growth, higher temperatures and drought conditions are expected to restrict productivity in many species. In the UK, climate change is expected to result in milder, wetter winters and hotter, drier summers, with more extreme weather events. For agricultural crops, the effect of increased carbon dioxide and temperature on the yield of arable crops is predicted to be broadly neutral. The warmer climate will provide opportunities for crop diversification, offering an increasing range of crops for industrial uses, such as sunflower and Kenaf.

4.31 However the coverage of some crops will alter or be restricted. In the case of hemp for fibre and other non-food uses, the increasingly dry climate will lead to a decrease in hemp production in southern England and a concurrent potential increase in northern regions. The distribution of short rotation coppice is projected to decrease over time, shifting west and north, away from eastern, southern and central England by 2080, while Scotland, Northern Ireland and Wales continue to offer suitable growing conditions (Figure 3).

4.32 Carbon and energy analyses will continue to play an increasingly important role in assessing the relative effectiveness of particular feedstocks and technologies in reducing carbon emissions. Current assessments indicate that woody biomass, from trees, short rotation coppice and miscanthus, offers the greatest carbon savings per hectare, with biofuels produced from oilseed rape and wheat showing significantly lower savings. However, second generation biofuels are expected to alter this picture.

Policies on Sustainability

4.33 The carbon savings offered by different transport biofuels and the wider environmental impacts of their production can vary significantly. We wish to move as quickly as possible to a system where only those biofuels which can be shown to have come from sustainable sources are eligible for Renewable Transport Fuel Certificates under the RTFO. Initially, transport fuel suppliers will be required to report on the greenhouse gas balance and environmental impacts of the biofuels they put on the market. We are already working with the European Commission and other Member States to develop robust verifiable sustainable standards for biofuels. The RTFO consultation[80] put forward some possible ideas on the scheme's potential future development and we invited views. No decisions have been taken but a future strategy could include linking Renewable Transport Fuel Certificates to the level of greenhouse gas saving achieved by the fuel. Further, credits under the RTFO could be made conditional on biofuels meeting certain minimum environmental and

Figure 3: Climate suitability maps for short rotation coppice under the UKCIP02 high-medium emissions scenario for the baseline and the time slices 2020, 2050 and 2080. Black shading showing potential distribution.

Baseline 2020 2050 2080

80 http://www.dft.gov.uk/consultations/open/draftrtfo/rtfo – RTFO consultation February 2007

social standards. This could include increased use of co-products from biofuel production to maximise land use efficiency and carbon savings.

4.34 We believe that it is important to ensure that co-firing and large dedicated biomass electricity schemes are sustainable over the long term. We will, therefore, require co-firers and developers of larger biomass electricity power stations to submit to the Regulator an annual report on the biomass they have used, its origins and whether it has been sourced under any existing codes of practice or accreditation schemes, e.g. the UK Woodland Assurance Standard[81] and the Roundtable on Sustainable Palm Oil.[82] We are also considering these issues in relation to biomass heat.

Policies on Waste

4.35 The soon to be published Waste Strategy (2007)[83] sets out a policy framework aimed at achieving the optimal balance between material recovery for re-use and recycling and energy recovery, from waste biomass. Measures include optimising the way waste is collected – with a new emphasis on the separate collection of food waste – and treated. The main elements of waste biomass are green garden waste, paper, card, food, and waste wood.

4.36 A key aim is to reduce the carbon impact of waste management. The continued drive to divert biodegradable waste from landfill will reduce landfill methane emissions (3% of total UK greenhouse gas emissions), with material and energy recovery also offsetting primary material production and conventional power generation. The work of the International Energy Agency on the use of biodegradable and combustible waste for energy production as an alternative to landfill, through its Bioenergy Implementing Agreement, is directly relevant to this aim. Recovering energy from waste biomass will help towards our overall renewables targets, as well as providing an indigenous, secure energy source. Electricity generated from combustion of waste biomass contributed about 6 per cent of renewable electricity generation in the UK in 2005. This is an essential component of a well-balanced energy policy, with many European countries making greater use of biomass waste as an energy source than in the UK.

4.37 We want to derive greater carbon and energy benefits from biomass waste streams, such as wood and food waste via anaerobic digestion and from the biomass content of waste derived fuels, and encourage use of the most efficient technologies to achieve this objective. This should include recovery of heat as well as electricity where practicable. Local authority projects to divert biodegradable municipal waste from landfill will also result in the production of substantial volumes of waste derived fuels, with an estimated 5 million tonnes being available by 2013. This will be of interest both to power generators wanting to co-fire low carbon fuels and energy intensive industries looking to alternative energy supplies. The Government's Energy White Paper[84] places energy from waste in a wider energy policy context.

4.38 Anaerobic digestion is a preferred technology for the recovery of energy and material from source-segregated biowaste, and is discussed more fully in section 5. Anaerobic digestion offers significant climate change and energy benefits over landfilling or landspreading rapidly degrading wastes, such as food/kitchen wastes, whilst the land application of compost may have the potential to sequester carbon in soils and to improve soil fertility, which could confer additional climate change benefits. With the majority of food waste produced in the UK currently being landfilled it is important to make much greater use of this resource. Consequently we are taking a range of actions to support a wider uptake of anaerobic digestion.

4.39 A number of waste to energy technologies are supported through the Renewables Obligation to stimulate a greater contribution to renewable electricity generation from waste biomass. These are anaerobic digestion, gasification, pyrolysis and energy from waste with good quality combined heat and power. Support is received for the biomass fraction of the feedstocks used. Fuels over 90% biomass by energy content, such as waste wood, are also eligible for ROCs. We believe that banding the Renewable Obligation (RO) presents the opportunity to provide a more targeted level of support to the different renewables. It will also help bring forward a diverse mix of renewable schemes including those waste to energy technologies that are currently eligible. We are working with the regulator (Ofgem) to overcome some of the technical barriers to accreditation for eligible waste to energy schemes.

4.40 Implementation of the EU Nitrates Directive (1991/676/EC), the Water Framework Directive (2000/60/EC), the Integrated Pollution Prevention and Control Directive (1996/61/EC) and the Waste Incineration Directive (2000/76/EC) will help to minimise negative impacts on the environment from the increased use of waste for bioenergy production.

81 www.ukwas.org.uk
82 www.rspo.org.uk
83 http://defraweb/environment/waste/index.htm
84 www.dti.gov.uk/energy/whitepaper

5. Biomass use for energy

5.1 Biomass resources can be used for a range of energy applications including heat, electricity generation, combined heat and power, the production of gaseous and liquid fuels for transport. The main driver for the use of biomass is the abatement of greenhouse gas emissions and avoidance of methane emissions that would otherwise result from the disposal of waste biomass to landfill. An important consideration in their utilisation is the cost effectiveness of these differing options (in terms of £/tC abated). Table 5 below gives an outline of the carbon dioxide abatement costs for a range of energy generation types using biomass:

5.2 Assessing the economic viability of biomass energy is difficult because it is a developing option for which the prices of biomass supply and of the conversion technologies for producing heat, power,

Table 5 – Comparison of the CO_2 abatement cost for energy generation using biomass[85]

Application	Biomass type	Load (%)	Fossil fuel displaced	CO_2 abatement cost (£/tCO_2)		
				Low/ High	Central	High/ Low
Large industrial boiler	Chip	30%	Gas	43	76	84
Small commercial boilers	Pellet	30%	Gas	56	78	94
Small commercial boilers	Chip	30%	Gas	60	84	93
5% co-firing with wood arisings on existing coal power plant	–	60%	Gas	59	98	142
ROC Buyout price (£33/MWh) in 2006/07					103	
10% co-firing with miscanthus on existing coal power plant	–	60%	Gas	72	111	155
10% co-firing with miscanthus on new coal power plant	–	60%	Gas	78	112	152
10% co-firing with SRC on new coal plant	–	60%	Gas	89	124	163
10% co-firing with SRC on existing coal plant	–	60%	Gas	88	128	172
Domestic heat	Pellets	–	Oil	86	127	165
Biodiesel			Diesel	58	137	310
ROC Trading price (£45/MWh)					141	
Dedicated power generation using wood arisings		80%		155	200	249
Domestic heat	Pellets	–	Gas	180	205	225
Bioethanol from wheat			Petrol	70	152	333

85 Taken from Working Paper 1 – DTI report on the Economics of Biomass

etc. are quite fluid. These estimates show biofuels produced from UK feedstocks to be an expensive abatement option in the near term. Abatement costs for second generation bio-fuels could be substantially lower, of the order of £30-50/tCO_2, but have not been included in the table which is aimed at comparing current options. However, using a scenario based analysis,[86] the most cost effective biomass options (in order of cost effectiveness) are expected to be:

- Energy from waste, that would command a gate fee for alternative disposal, to produce
  - Heat or CHP
  - Electricity
- Energy from non-waste biomass:
  - Replacement of oil for commercial/industrial heat and CHP in high load applications.
  - Replacement of oil for commercial/industrial heat in seasonal load applications.
  - Medium scale anaerobic digestion of agricultural arisings for power generation or CHP replacing oil heating.
  - Replacement of gas for commercial/industrial heat in high load applications.
  - Co-firing on new coal fired power generation with Carbon Capture and Storage.
  - Replacement of gas for commercial/industrial heat in seasonal load applications.
  - Small scale anaerobic digestion of agricultural arisings for power or CHP replacing oil heat.
  - High load district heating replacing oil.
  - Co-firing on existing and new coal fired power generation plant.
  - Replacement of individual domestic oil boilers with biomass.
  - Electricity generation from power plant fired exclusively on biomass.
  - Replacement of individual domestic gas boilers with biomass.
  - First generation transport biofuels.

5.3 These results highlight the importance of advancing biomass heat alongside existing measures to encourage biomass utilisation for power generation and transport. However, cost effectiveness figures are highly dependent on the relative cost of biofuels and conventional fuels. Moreover, cost effectiveness is not the sole criterion for determining strategy for the use of biomass. Other important considerations are the rate of growth in demand and the cost of other low carbon options. For example, the rate of growth, and overall potential for substituting biomass for oil heating is likely to be limited, which suggests that other markets such as co-firing should also be pursued. The other environmental impacts of increased biomass use must also be taken fully into account, such as the impact of fuel switching on air quality (see para 5.14 below). There are circumstances, such as in road transport, where biomass may be cost effective compared to other transport options, although it may appear less attractive than biomass applications in other energy use sectors.

Renewable heat and cooling

5.4 Generating heat accounts for roughly 47% of the UK's total energy consumption by end-use, and 41% of the UK's total carbon emissions (equivalent to 61 MtC annually).[87] Three quarters of that energy[88] is used for space and water heating, primarily in the domestic sector. There are a range of sources of renewable heat, but biomass is the only fuel that can be used over the whole range – from very small-scale domestic units to large-scale district heating systems. It can also be used for industrial process heating and combined heat and power projects.

5.5 Around 1% of heat is currently generated from renewable sources. Annex E shows the current distribution of biomass power, heat and CHP installations. Despite the potential for a significant increase, the amount of renewable energy supplied as heat has declined in recent years both as a proportion of the whole and in absolute terms. The largest energy market for biomass remains the residential consumption of logs for space heating, along with the industrial use of surplus clean wood for space and process heat generation. However, recent tightening of environmental legislation has closed many of these installations as it has been cheaper to switch to fossil fuel than replace or upgrade the wood heat combustion system, to meet the legislation.

5.6 We are committed, through the Climate Change and Sustainable Energy Act,[89] to promote the use of renewable heat. Renewable heat is already competitive in some situations and has benefited from capital grant funding made available through the Low Carbon Buildings Programme and

86 Taken from Working Paper 1 – DTI report on the Economics of Biomass
87 www.defra.gov.uk/environment/statistics/land – data for 2005
88 Also by end use
89 http://www.opsi.gov.uk/ACTS/acts2006/20060019.htm

the Bioenergy Capital Grant scheme. We have also commissioned Ernst and Young to analyse the case for long term support for the renewable heat sector and are considering their conclusions.

Power production

5.7 Biomass has significant potential to contribute to renewable electricity and carbon abatement. Currently around 4.6% of our electricity comes from renewable energy sources with biomass providing around half of that supply. Electricity generated from biomass is eligible for support under the Renewables Obligation (RO). DTI and the Big Lottery Fund have provided support through the Bioenergy Capital Grants Scheme for the establishment of dedicated biomass power stations, such as those under construction in Lockerbie and Wilton.

5.8 The RO has been successful in stimulating deployment of the most economic renewable technologies. In order to increase deployment further and increase efficiency, we are proposing to move the RO away from being technology neutral by providing more targeted levels of support. It is proposed that technologies with similar economics will be given similar levels of support to minimise complexity. New projects in technologies that are more economic and no longer need the full support of a ROC will be banded down whilst others, such as biomass CHP, may be banded up.

Co-firing

5.9 We consider that electricity generation from coal is likely to remain part of our generating mix for the foreseeable future. In this market scenario, where coal continues to play a role in electricity generation, we want to abate the carbon emissions from coal plant as much as possible. We believe that co-firing of biomass and Solid Recovered Fuels (SRF) in Waste Incineration Directive (WID) compliant plant has the potential to play a long-term role in this context, as part of a wider carbon abatement strategy for fossil fuels. Co-firing of biomass can also help in developing biomass supply chains. We also consider that, depending on developments within the carbon market, it may in the future be possible to remove co-firing entirely from the RO and support it through the carbon price alone.

Combined heat and power

5.10 Good Quality Combined Heat and Power (CHP)[90] is a carbon-efficient process which puts to use the heat produced as a by-product of electricity generation. CHP increases the overall efficiency of fuel utilisation compared to conventional forms of generation, so delivering carbon savings. Typically the process is fired by fossil fuels, though biomass CHP is growing in importance. We have set a target of 10GW of Good Quality CHP by 2010 and have a number of support mechanisms in place to help secure this objective.

5.11 A number of economic factors affect the viability of CHP. The more consistent the demand for heat, the more economic CHP can be. Consequently, the best sites for CHP are industrial sites in continual operation. Community-scale projects are most effective where a range of different heat and cooling demands (residential flats, office blocks, municipal buildings) are aggregated within the system to ensure constant, levelled demand.

5.12 The costs of generating electricity using CHP are often higher than for standard centralised generation, even though there is a financial return for the heat that can be sold. To reward the carbon saving Good Quality CHP offers, and to encourage the growth of CHP capacity in the UK, we have introduced a number of support measures, including:

- favourable allowance allocations under phase II of the EU ETS
- exemption from the Climate Change Levy
- business rates exemption
- enhanced capital allowances for plant and equipment with plans to expand eligibility to support SRF combustion capacity
- ROC eligibility for the biomass element of wastes used in conventional energy from waste plants that utilise CHP

In addition to these measures to make CHP more financially attractive, we have taken steps to increase awareness of the opportunities for CHP amongst users of heat e.g. industrial intensive energy users. Since the publication of the Energy Review,[91] DTI has published the revised guidance for power station developers which includes industrial heat maps.

5.13 Defra will produce guidance for the public and private sector to ensure that anyone replacing a mid-sized furnace as part of a boiler plant (over 400kW) is aware of the potential for CHP.

90 Good Quality CHP denotes schemes that have been certified as meeting the energy efficiency criteria prescribed by the UK's CHP Quality Assurance Programme (CHPQA). Such schemes are entitled to certain financial benefits. Further information on the programme can be found at www.chpqa.com.

91 http://www.dti.gov.uk/files/file31890.pdf

Air quality

5.14 Some of the potential air quality risks of bioenergy production are managed by legislation, such as energy production from biomass[92] elements in waste. This includes the EU Air Quality Framework and "daughter" Directives[93] (which set legally binding limit values for a number of pollutants), and the Clean Air Act 1993.[94] Given our intention of expanding biomass use for energy, we need to consider carefully the potential impact of this increase in use on air quality and of pollutants on public health. Our Air Quality Strategy[95] sets objectives for nine pollutants (including those for which limit values have been set at a European level), in order to protect public health and the environment. The aim of this strategy is to "make sure that everyone can enjoy a level of ambient air quality in public places which poses no significant risk to health or quality of life".[96] We are concerned to ensure that the use of biomass to generate energy does not have a detrimental impact on air quality, particularly where this would have a significant impact on public health or compromise our ability to meet legal obligations under air quality legislation.

5.15 It is our aim to ensure that the appliances installed in the UK as part of the implementation of this Strategy are modern and, largely, low in pollutant emissions. Modern automatically stoked clean wood chip or pellet appliances tend to be more efficient and have lower emissions of particulate matter (PM) and PAH than older log burning appliances, but may give higher polluting emissions than equivalent gas fired appliances. Overall, there has been significant progress in the design of such appliances in recent years. We will ensure that when promoting the use of biomass, account is taken of combustion emissions and the impact of pollutants on public health. However, any move away from centrally generated electricity to smaller, locally based plant (such as CHP), will inevitably increase emissions in urban areas.

5.16 There are currently around 140 models of biomass stoves/boilers which meet the requirements of the Clean Air Act 1993 and have been exempt for use in UK smoke control areas. However, there are currently no recognised European-wide standards for levels of particle or other emissions from biomass appliances. We will consider if the British Standards Institute, through their membership of the CEN Committees, might initiate discussion on the development of a European-wide standard for particle emissions from biomass appliance, without compromising our current testing and approvals regime for the Clean Air Act.

5.17 An analysis of the air pollution impacts of biomass combustion, comparing this to the impacts of coal, oil and gas combustion, was carried out for the Scottish Executive in 2006.[97] This found that the fossil fuel that biomass energy technologies replace is very important in determining whether air pollution emissions increase or decrease. Displacement of coal results in significant reductions in sulphur dioxide (SO_2), as well as reductions in PM, carbon monoxide (CO), oxides of nitrogen (NOx) and non-methane volatile organic compound (NMVOC) emissions, whereas displacement of oil tends to lead to decreases in SO_2 emissions, but increases in other emissions such as PM or NOx. Substitution of natural gas with biomass, on the other hand, generally leads to increases in emissions of all major pollutants. Although emission of some pollutants is determined by fuel characteristics, the choice of electricity/heat generation technology, including abatement systems, can also have a significant impact on non-greenhouse emissions and, in some instances, the technology can be more relevant than fuel characteristics. There are substantial gaps in reliable emission data for biomass combustion for energy. The Government, led by Defra, is working to increase the level of reliable emissions data, and to quantify the impact of the implementation of this strategy on non-greenhouse emissions, air quality, and the UK's ability to comply with mandatory air quality limit values.

Anaerobic Digestion

5.18 Anaerobic digestion has significant potential to contribute to our climate change and wider environmental objectives. It is a well-proven renewable energy technology. At the same time, it can reduce greenhouse gas emissions by capturing methane from the decomposition of organic materials, such as livestock manures and slurries, sewage sludge and food wastes. Methane is a greenhouse gas with a global warming potential 21 times that of carbon dioxide over a 100-year

92 http://europa.eu.int/eur-lex/en/consleg/pdf/2000/en_2000L0076_do_001.pdf
93 http://ec.europa.eu/environment/air/existing_leg.htm These set mandatory Limit Values on the concentrations of a number of key air pollutants.
94 http://www.opsi.gov.uk/ACTS/acts1993/Ukpga_19930011_en_1.htm
95 http://www.defra.gov.uk/environment/airquality/strategy/strategy.htm
96 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland; January 2000.
97 http://www.scotland.gov.uk/Publications/2006/09/22094104/2

time horizon.[98] Annex F shows the location of current landfill gas and sewage gas installations.

5.19 Anaerobic digestion involves harnessing the natural process whereby organic matter is broken down by bacteria in the absence of oxygen. The materials ferment in a closed vessel and produce a biogas which is a mixture of about 60% methane and 40% carbon dioxide. This can be used as a renewable energy source, both for heat and power, as a transport fuel, or upgraded for pipeline injection and local distribution. The treated liquid (or digestate) can be used as a fertiliser. Anaerobic digestion offers the opportunity to reduce greenhouse gas emissions from agriculture by capturing methane from manures and slurries. Similarly, it can help to reduce emissions from landfill by diverting organic waste, especially food waste. Other environmental benefits, when anaerobic digestion is operated well and the digestate applied correctly to land, include improved air and water quality.

5.20 We will work with stakeholders to drive a faster growth in the use of this technology by local authorities, businesses and farmers. Our objective is to stimulate and develop the markets for anaerobic digestion and its products, and to address the administrative and technical challenges which may hamper its development. Key actions set out in the Anaerobic Digestion Working Paper are outlined below.

5.21 We recognise that there is currently a market failure which is inhibiting the optimal investment in the anaerobic digestion sector. We are therefore examining whether there is a role for Government intervention to help overcome this, and whether economic instruments might have a role to play. In particular, three complementary areas of work are to examine:

- the contribution that Renewable Obligation Certificates (ROCs) could make on the demand side to encouraging the greater use of anaerobic digestion;
- the case and prospective mechanisms for long term support for the renewable heat sector (see paragraphs 5.4-5.6 for further details); and
- possible means to support the development of local infrastructure and supply chains.

5.22 The digestate (treated liquid) from anaerobic digestion contains useful nutrients and can be used as a fertiliser and soil conditioner. To facilitate the development of the market for digestate:

- The Environment Agency and WRAP aim to develop a standard and protocol for digestate by Spring 2008.
- WRAP will support the development of the market for digestate alongside its work to establish markets for waste-derived compost.

5.23 There are also a number of administrative and technical challenges faced by potential operators of anaerobic digestion plants which we are determined to overcome. We will:

- encourage and facilitate communication between interested parties in industry, regulators, government delivery bodies and non-governmental bodies about meeting these challenges;
- work with stakeholders to develop and disseminate information on best practice and technology for the use of anaerobic digestion in a way that is both cost effective and beneficial to the environment, for example through Defra's New Technologies Demonstrator Programme[99] and through advice to farmers; and
- build on our existing research to improve the contribution of anaerobic digestion technology to reducing greenhouse gas emissions and delivering other environmental benefits.

5.24 As well as our work to support anaerobic digestion domestically, the UK is taking a leading role in driving forward thinking about the role of anaerobic digestion internationally, in particular through the international Methane to Markets Partnership. We are also looking to learn from the experience of other countries through, for example, IEA collaboration on biogas and landfill gas.[100]

5.25 A cross-cutting project team will coordinate delivery of the above actions within Defra. It will also work with other key Government departments and stakeholders to identify and further address barriers and maximise the synergies between the different markets in which anaerobic digestion has a contribution to make.

98 This figure is the 1995 Global Warming Potential (GWP) value. Whilst the GWP values have since been updated, the Kyoto Protocol states that "global warming potentials used by Parties to the Protocol should be those provided by the Intergovernmental Panel on Climate Change in its Second Assessment Report ("1995 IPCC GWP values")".

99 http://www.defra.gov.uk/environment/waste/wip/newtech/dem-programme/index.htm

100 www:iea-biogas.net

6. Biomass use for transport

6.1 The use of biomass to produce biofuels for transport has a significant potential to deliver carbon savings in a sector where other renewable sources such as wind, solar and tidal power are not practical. The Renewable Transport Fuel Obligation[101] (RTFO), due to be introduced in April 2008, will be one of the main policy instruments in the transport sector to reduce greenhouse gas emissions and to increase the use of renewable fuels, helping to meet our international obligations under the Kyoto agreement and the EU Biofuels Directive. It will apply across the whole of the UK, to any road transport fuel supplier who supplier's more than 450,000 litres of fossil fuel per annum to the UK market.

6.2 As has been highlighted, the RTFO will place a legal requirement on transport fuel suppliers to ensure that 5% (by volume) of their overall fuel sales is from a renewable source by 2010/11, with staged required levels of 2.5% (by volume) for 2008/9 and 3.75% (by volume) in 2009/10. Once the 5% level is reached it is estimated that it will save around a million tonnes of carbon per annum, which is roughly equivalent to taking a million cars off the road.

6.3 The inclusion of significant proportions of biofuel in the UK fuel market will require new production and supply infrastructure. This will include new tanks for storage and extensive investment at fuel terminals to cater for bioethanol which cannot be transported through the existing pipeline network due to its hygroscopic nature.

6.4 Biofuels have slightly different combustion properties from conventional fuels and there is evidence to suggest that high proportions of them in road fuel can increase the amounts of local air pollutants emitted, unless the fuel is stored and used appropriately. Raising the level of bioethanol in petrol, for example, may increase emissions of volatile organic compounds from vehicle exhausts and from fuel evaporation. These compounds, especially acetaldehyde, can promote the formation of ozone – a highly reactive greenhouse gas that can be detrimental to ecosystems and harmful to human health.

6.5 Further, the raw materials and manufacturing processes for biofuels can vary significantly, so the production and use of each biofuel product will provide different carbon savings and environmental impacts. We are keen to encourage the development and use of those biofuels that offer the highest levels of carbon savings with the minimum adverse environmental impact. The UK is at the European forefront of work to develop sustainability reporting criteria and carbon savings methodologies. These are important aspects for the RTFO and globally, and we are encouraging Europe to take account of our expertise in this area at a global level.

6.6 The RTFO will place a mandatory requirement on obligated companies to report on the carbon savings offered by their biofuels, and on the wider environmental and social impacts arising from the growing and processing of their biofuel feedstocks. This is intended to address the risk that biomass could be produced from unsustainable sources which could potentially undermine environmental benefits. While it is anticipated that imported biofuels will contribute to UK targets under the RTFO, an enhanced UK biofuel industry (see Section 4) will contribute to the UK's security and diversity

101 http://www.dft.gov.uk/consultations/open/draftrfto/rfto

of supply as well as benefit the economy, particularly the rural economy.

6.7 We use other support mechanisms for biofuels, which remain alongside the RTFO, including:

- Fuel duty incentives – the 20 pence per litre fuel duty incentive on biodiesel and bioethanol has been extended to 2010.
- Government Grant Programmes: The refuelling infrastructure grant programme aims to increase the number of alternative refuelling stations for road vehicles. It provides grants towards the cost of installing alternative refuelling points including biofuels as well as other alternative fuels such as hydrogen and natural gas.
- Regional Selective Assistance (RSA)/Selective Finance for Investment grants: A RSA grant helped to establish the UK's first major biofuel plant in Scotland, and other Regional Development Agencies have made offers under the English equivalent (Selective Finance for Investment).
- Support for the direct refining of vegetable oils at oil refineries: We are exploring whether direct refining of vegetable oils at oil refineries might be encouraged through the tax system.
- Piloting novel approaches: We are currently assessing two expressions of interest for a pilot project to examine the potential for using fuel duty incentives to support the use of biomass in conventional fuel production.

6.8 As mentioned at Section 3, we have been consulting on the detailed implementation of the RTFO and inviting views on how it might evolve over time.[102] We have made it clear that we are committed to increasing the level of the RTFO beyond 5% after 2010/11, but only provided certain conditions are met:

- Confidence that biofuels will be produced in a sustainable way, so that they deliver the maximum practicable carbon savings with the minimum practicable adverse environmental impacts;
- Certainty that the use of biofuel blends higher than 5% will not lead to mechanical problems in vehicles, particularly for owners of older cars which were not designed to run on biofuel mixtures;
- Confidence that the costs to consumers will be acceptable, both in terms of prices at the pump, and in terms of wider economic impacts, including, for example, the impacts on food prices and other industries which make use of the same feedstocks.

6.9 We believe it is important to encourage technical innovation in the field of biofuels. "Second generation" biofuels (i.e. biofuels generally produced from feedstocks other than food crops and using a number of advanced processes, including gasification and the use of enzymes to break down the cellulose in the feedstock) have the potential to improve carbon savings, and potentially offer other benefits, including contributing to greater diversity of energy supply (since they can be produced from much greater range of feedstocks), and, where "green waste" is used as a feedstock, reducing pressure on land and the amount of waste that goes into landfill. Further measures on technology development for transport are set out in the Low Carbon Transport Innovation Strategy[103] published alongside this strategy.

6.10 The majority of these processes to produce improved biofuels are currently not proven at commercial scale, and their costs are currently prohibitively high. However, this is likely to change over time provided the right incentives are put in place to allow the necessary development. The Government is considering ways to assist this process through the future development of the RTFO and other measures.

6.11 Before increasing the level of the RTFO beyond 5%, the Government will also want to be satisfied that this represents an effective use of our biomass resources. Alternative uses of biomass, which can often deliver greater carbon savings at lower cost than producing high quality liquid transport fuel, include using biomass as a substitute for fossil fuels in the generation of electricity and heat, and in the oleo-chemical industry to produce products that would otherwise need to be produced from virgin oils. Consideration of these issues will also take account of the European Commission's expected proposals for revising the Biofuels Directive (2003/30/EC) as part of its work to take forward the agreement reached with provisos very similar to our own at the Spring Council for a 10% biofuel target by energy content by 2020.

6.12 In addition to their use in road transport, biofuels can also potentially be used in other transport modes including rail, shipping and, in the longer term, aviation. Further information on the potential use of biofuels in these transport modes can be found in the relevant sections of the Low Carbon Transport Innovation Strategy.[103]

102 The RTFO consultation closed on 17 May 2007.
103 www.dft.gov.uk/pgr/scienceresearch/technology/

7. Promoting innovation

7.1 Bioenergy research and development is required, both to improve the efficiency of the energy conversion and to reduce the delivered cost of the fuels used. The technology used for heat and power generation is, primarily, well-established combustion technology, which can provide heat and power reliably but at low efficiencies where compared to the equivalent larger-scale fossil fuel generation technologies. Further research and development will, therefore, be required into potentially more efficient energy generation technologies such as gasification and pyrolysis.

7.2 The need to reduce the delivered cost of fuels will lead to the development of a wider range of fuels – covering the whole biomass supply chain – from virgin crops to waste materials. In the case of energy crops, establishment of which continues to be supported through the Rural Development Programmes, we will also need to continue the research being carried out to improve the yields of these materials and their suitability for energy generation.

7.3 We have already invested in energy technology development through a range of instruments covering the innovation chain from fundamental research to deployment of technologies. Examples of support in this sector are the Supergen Bioenergy consortium, the Technology Programme and the Bioenergy Capital Grants Scheme. There is also a significant amount of work internationally through the International Energy Agency's Bioenergy Implementing Agreement, the EU Framework Programme and the Global Bioenergy Partnership.

7.4 This investment in energy technology development is set to rise in support of the UK's energy and climate change goals. This investment is available to a portfolio of emerging low-carbon energy technologies, including the development of advanced biomass conversion technologies.

7.5 Funding for pure research through the Research Councils is increasing to £70mpa by 2007-08. In addition, the new Energy Technologies Institute has a potential £1bn budget over the next decade. The Institute is a joint venture partnership which brings

together public and private sector R&D in the UK to set strategic direction and fund its delivery. The objectives of the Energy Technologies Institute are to:

- increase the level of funding devoted to R&D in low-carbon energy technologies to meet UK's energy policy goals, both domestically and internationally;
- deliver R&D that facilitates the rapid commercial deployment of cost effective, low carbon energy technologies;
- provide better strategic focus for commercially applicable energy related R&D in the UK;
- connect and manage networks of the best scientists and engineers both within the UK and overseas to deliver focused energy R&D projects to accelerate eventual deployment; and
- build R&D capacity in the UK in the relevant technical disciplines to deliver the UK's energy policy goals.

7.6 The Institute opens during 2007 and reaches full strength next year. It will work closely with the new Technology Strategy Board. The Technology Programme (the predecessor of the now-independent TSB) has been a major source of support for biomass development. Low-carbon energy project calls by the new Technology Strategy Board will continue unchanged during 2007 to ensure a smooth transition from the Technology Programme.

7.7 In June 2006, we announced the creation of a new cross-Government Environmental Transformation Fund to invest in low carbon energy, including the demonstration and deployment of low-carbon energy technologies. Details will be announced during 2007. Establishment of the Fund may provide an opportunity to bring together the DTI and Defra capital grant programmes to support the development of biomass.

7.8 On 8 March 2007 we announced an extra £20m for research into green bioenergy. This will more than double the budget for research in this area. The initiative by the Biotechnology and Biological Sciences Research Council (BBSRC) will take total BBSRC funding to £36m over the next five years. It will support the build up of research capacity into how bioenergy can help replace fossil fuels with renewable, low-carbon alternatives. The UK already has some of the leading experts in photosynthesis – the exploitation of energy from plants and microbes from sunlight. The funding will look at expanding the capacity and skills base allied to turning laboratory excellence into products and processes.

Biofuels

7.9 As highlighted in Section 6, we believe that it is important to encourage technical innovation in the field of biofuels. 'Second generation' biofuels have the potential to improve carbon savings, and potentially offer other benefits, including contributing to greater diversity of energy supply and, in some cases, reducing pressure on land and the amount of waste that goes into landfill. We are considering ways to encourage and facilitate these more advanced biofuels becoming a commercial reality, including as part of the future development of the RTFO and other measures.

Biorefineries

7.10 As part of the move to a low carbon economy, we need to make optimum use of plants and other biological resources in a way which links bioscience with commercial development to deliver the outcomes we need for industry, society and the environment. This will involve:

- Large-scale substitution of bio-based products for those based on petrochemicals, and other non-renewable sources, across a wide range of industrial products
- Integration of fuel and energy production with other bio-based materials in biorefineries – co-streams to add value e.g. British Sugar's biorefinery in Wissington which will produce sugar, betaine (animal feed supplement or haircare ingredient), bioethanol, CO_2 and heat to produce tomatoes and electricity for the Norfolk grid.
- New-generation technologies for biofuels and other products of biorefineries fully operational in the UK.

7.11 We expect that biorefineries and new-generation biofuels will be deployed within the next 5 years, with scaling-up and wide market penetration moving on through the 2010-2020 decade. The announcement in February 2007 of funding by the United States' Department of Energy towards biorefineries producing cellulosic ethanol will help to speed that process. For many bio-based products, such as polymers and construction materials, technologies are already largely proven and successful and wider deployment depends largely on industry acceptance and resolution of economic and societal barriers.

8. Next steps

8.1 This strategy has been developed against evolving UK and EU energy and renewable raw materials policies. The contribution the UK will be required to make to the new EU renewables and biofuels targets remains to be established through ongoing negotiations at the European level. In this context we cannot give absolute clarity on the role biomass will be expected to play in meeting these targets. However, the direction in which we need to move is clear and this strategy seeks to promote development of biomass which is consistent with this.

8.2 Our knowledge of the role biomass currently plays in delivering the UK's requirements is not perfect. We will continue to work in collaboration with all stakeholders including farming, industry and environmental interests, regional and local bodies and planners to improve our knowledge. We will also be undertaking further work to establish more clearly how the UK's aims and objectives for biomass will be affected by EU and other international developments.

8.3 The impact of increased biomass use must be sustainable and the impact of this strategy on the environment and the utilisation of land for food production will be monitored closely. We will involve stakeholders closely in this process. However, given the evolving policy context it will be necessary to fine tune our objectives and actions flowing from them to take account of changing national and international priorities. In the longer term, our ambition is to promote international collaboration on research and good practice which delivers more efficient and sustainable bioenergy production and use.

8.4 Tackling climate change requires a long term strategic approach. Addressing the problems of today will not necessarily tackle the problems of the future. We will, therefore, continue to work closely with stakeholders to identify long term solutions.

Working papers

In developing this strategy, work has been undertaken in a number of areas to inform the conclusions reached. This work has been collated in a series of Working Papers as follows:

- WP 1 Economic and carbon/energy analyses of bioenergy sources
- WP 2 Report on distribution of bioenergy crops in the UK
- WP 3 Anaerobic digestion

These are available at: http://www.defra.gov.uk/environment/climatechange/index.htm

Annex A

Quantification of existing[104] UK biomass resource and its potential for energy generation

Biomass source Energy conversion efficiency (1)	Available tonnage (dry tonnes)	Energy contained Million tonnes of oil equivalent (Mtoe)	in biomass (TJ) (10)	Potential energy generation Electricity only 30% GWh_e	Heat only 85% GWh_h	Heat & Electricity 85% $GWh_{e\&h}$
A) 'Dry' materials						
Sawmill conversion products and aboricultural arisings	1,312,000 (4)	0.57-0.66	23,616-27,552	1,968-2,296	5,576-6,505	5,576-6,505
Energy crops (short rotation coppice (willow/poplar) and miscanthus)	155,463-222,787 (6)	0.07-0.09	2,757-3,955	230-329	651-933	651-933
Cereal straw	3,000,000 (7)	0.97-1.19	40,500-49,500	3,375-4,125	9,563-11,688	9,563-11,688
Paper and card (11)	3,132,000	0.31-0.82	12,950-34,450	1,080-2,870	3,060-8,130	3,060-8,130
Garden/plant waste (11)	3,429,000	0.34	14,400	1,200	3,400	3,400
Waste wood (11)	5,563,000 (5)	2.21	93,000	7,790	22,070	22,070
Sewage sludge (dry solids)	340,000 (8)	0.12-0.16	5,134-6,800	428-567	1,212-1,606	1,212-1,606
Poultry manure – Meat birds (60% DM)	1,098,900 (10)	0.37	15,385	1,282	3,632	3,632
Sub-total:	18,030,363-18,097,687	4.96-5.84	207,742-245,042	17,353-20,459	49,164-57,964	49,164-57,964
B) 'Wet' materials (Anaerobic Digestion)						
Typical AD conversion efficiency rates:			See note (3)	40%	85%	80%
Poultry manure – egg laying flock (30% DM)	369,000 (9)	0.06-0.12	2,546-4,981	280-550	600-1180	570-1110
Dairy cattle slurry (10% DM)	2,016,000 (9)	0.28-0.30	11,592-12,600	1,290-1,400	2,740-2,980	2,580-2,800
Pig manures (10% DM)	514,500 (9)	0.07-0.08	2,809-3,344	310-370	660-790	620-740
Food waste (11)	10,040,000	0.21-0.38	9,000-16,000	750-1,360	2,140-3,860	2,010-3,630
Sub-total:	12,939,500	0.62-0.88	25,947-36,925	2,630-3,680	6,140-8,810	5,780-8,280
Total:	30,989,863-31,037,187	5.58-6.72	233,689-281,967	24,139-55,304	55,304-66,774	54,944-66,244

NB. the figures in brackets are explained further in the notes on pages 39 and 40.

104 Covers not only the currently used resource but also the existing resource which has yet to be exploited.

Data supplied by D.Turley, Central Science Laboratory except (11) provided by James Vause Defra

1) Wood for energy production, CHP and power plants. Danish Centre for biomass technology (www.videncenter.dk/uk/index.htm). This report presents data on current CHP efficiencies of electricity generation, heat only generation as well as CHP generation, with real data from several CHP plants in Denmark – figures for CHP and energy and heat split for CHP represent average values across a range of installations. Generation of heat alone should reach 85% conversion efficiency (district heating plant). Conversion efficiency of 30% assumed for electricity generation for UK steam turbine mass burn technology.

2) Efficiency figures assume more efficient spark ignition engine used for electricity generation (40% efficient) rather than Rankin cycle process (30% efficient). At least 80% energy conversion should be achieved in any CHP set-up (50:50 electric and heat (Environment Agency)). For heat only situation assumed 85% efficiency (from: Wood for energy production, Chapter 9, CHP and Power Plants. Danish Centre for Biomass Technology (www.videncentre.dk/uk/index)).

3) Energy from anaerobic digestion based on estimation of biogas production – figures used are based on current inefficient AD technologies and could theoretically increase (typically threefold) with appropriate technical development. With such development the gap between technologies would close (AD remains the only feasible route to economically exploit wastes at 30% DM or less (Don Ridley, Environment Agency).

4) Figures include biomass from sawmill conversion products and forest residues, (from Wood Fuel Resource in Britain, H. McKay et al. Current potential operationally available woodfuel resource (in the presence of competing markets (GB only)), plus the potentially exploitable resource of forest residues in Northern Ireland estimated to be 8,000 dry tonnes per year, plus 100,000 tonnes of sawmill co-products, DARD Renewable Energy Action Plan, January 2007. Figures exclude up to a further 1Mt (odt) (England only) of estimated annual potential biomass production from under-managed woodlands (England Wood Fuel Strategy, Forestry Commission 2007) which has yet to be fully characterised.

5) Wood recovered from all waste streams in the UK is estimated at 7.5 million tonnes annually. The majority, 6 Mt (80%) is currently disposed of to landfill. 1.2 Mt (16%) are recovered for reuse. Currently 0.3 Mt (4%) is used in energy from waste (EFW) plants (Carbon Balances and Energy Impacts of the Management of UK Wastes, ERM for Defra 2007). The figure for waste wood takes into account a potential increase in recycling of best wood to 3 Mt/annum. The remaining 4.5 Mt, assumed to be available for biomass energy generation, includes both 'clean' and contaminated wood. Energy may be recovered from contaminated wood, provided it is burned in a Waste Incineration Directive (WID) compliant facility.

6) Represents the area of energy crops in receipt of planting grants plus applications that have been approved to date under the following existing and historic schemes: Defra Energy Crop Scheme, Woodland Grant Scheme, Scottish Forestry Grants Scheme and the Northern Ireland Forestry Service Challenge Fund. This amounts to a total of 15,546ha for SRC and Miscanthus combined.

Yield ranges used:

The range of 10-15 odt/ha used in this analysis agrees with yield ranges presented in a review of Long Ashton's long-term trials work with willow clones and spacing trials (Willow Biomass as a Source of Fuel, Institute of Arable Crops Research. Long Ashton Research Station (now defunct) 10 pages (LARS 86/4, 1989)). Miscanthus crops over 3 years old (i.e. well established) should yield between 10 and 14 odt/annum (Nix Farm Management Pocket Book & Bical). These Miscanthus yield figures are relatively conservative as, under trial conditions, average yields of up to 18 t/ha have been achieved (MAFF funded work – Project NF0403 Miscanthus Agronomy final project report). However, 10-14 odt was taken as the likely Miscanthus yield range given that perennial energy crops may not always be placed on the best soil types.

SRC crops over 3 years old (i.e. well established) should yield up to 10.9 oven dried tonnes (odt) per annum (Agricultural Budgeting and Costings Book (Agro business Consultants Ltd, May 2004), and in the best cases up to 15t/ha (upper end of Rothamsted results (from work carried out by Black & Veatch for The Carbon Trust)).

Calorific values used:

A calorific value of 17.3 MJ/kg (dry weight basis) was used for Miscanthus, based on published analysis results (2003) by Energy Power Resources Ltd in work for the DTI (Miscanthus – Practical Aspects of Biofuel Development (Report for the DTI on work carried out under the DTI's New and renewable Energy Programme)). The calorific value of short rotation coppice (typically represented by Willow) is typically taken to be similar to that of deciduous wood (i.e. 17.9 MJ/kg (dry)). However, calorific values as low as 15 MJ/kg (Renewables East (www.renewableseast.org.uk)) and as high as 18.6 MJ/kg (dry basis) (DTI estimated average gross calorific values for fuels 2004 (www.dti.gov.uk)) have been quoted. In this updated analysis 18.6 MJ/kg was used for consistency with published figures in DTI Digest of UK Energy Statistics.

7) The UK cereal straw (wheat and barley) resource is significant (9-10 mt per annum) but much of this is recycled to livestock and much of the rest is ploughed into soil (it has a resource value as a fertiliser and organic matter supplement). However, in Eastern counties of England, a surplus is available. It is estimated, that up to 3m tonnes could be made available in the long term without disrupting livestock use/buying costs (agricultural waste mass balance: opportunities for recycling and producing energy from waste technologies (Biffa/C-Tech Innovation/FEC)). Currently only around 200,000 t/annum is burnt for energy.

8) In total 1,368,000odt sewage sludge was produced in the UK in 2004, this includes 878,000t spread on farmland and 150,000t used for land reclamation/restoration, 15,000t disposed of by landfill, 265,000t currently incinerated, plus 60,000t disposed of by other routes (Defra statistics – Estimated Sewage Sludge Arisings 2004). All sewage, other than that applied to land, is assumed to be available for energy generation.

9) Calculated from Defra livestock numbers (2005) and data on manure production presented in Managing Livestock Manures – making better use of livestock manures on grassland, Defra publication (ADAS/IGER/SRI). Clearly, these figures represent theoretical maxima availability for each manure type, as most will be recycled to land. The greatest opportunity to exploit such resources will be in areas of high stock density where there are limits on the ability to spread to land, due to environmental or logistical constraints.

10) All figures account for moisture content of parent biomass material.

11) Currently 11% of residual municipal waste in the UK has energy recovered from it, which (in England) may increase to about 27% by 2020 (7,535,000 tonnes on an 'as received' basis). (Future Perfect – Analysis of Britain's waste production and disposal account, with implications for industry and Government for the next 20 years (Biffa)). This assumption was used in conjunction with the approach used in the Waste Strategy review combined with the ERM report. The ERM report highlighted maximum recovery rates feasible based on international experience (table 5.1 in the main report: http://www.defra.gov.uk/science/project_data/DocumentLibrary/WR0602/WR0602_4750_FRP.pdf). This was used to derive a maximum amount of waste that could be recovered. Current recycling and composting and any future recycling feasible identified by WRAP in the waste strategy review was deducted from this total. This gives us a maximum achievable energy recovery level.

Annex B

Potential Carbon savings arising from substitution of grid electricity and heating oil (for energy generation) based on existing biomass resources and current energy conversion efficiencies (based on data presented in Annex A).

Biomass source	Potential Carbon savings (million tonnes C)			Additional carbon savings from avoided landfill (mtce)
	Electricity only	Heat only	Heat & Electricity	
'Dry' materials				
Sawmill conversion products and arboricultural arisings	0.23-0.27	0.38-0.44	0.46-0.54	
Energy crops (short rotation coppice (willow/poplar) and miscanthus)	0.03-0.04	0.04-0.06	0.05-0.08	
Cereal straw	0.40-0.48	0.65-0.80	0.79-0.97	
Paper and card (3)	0.13-0.34	0.21-0.55	0.27-0.71	0.59
Garden/plant waste (3)	0.14	0.23	0.32	0.13
Waste wood (3)	0.91	1.50	2.05	0.45
Sewage sludge (dry solids)	0.05-0.07	0.08-0.11	0.10-0.13	
Poultry manure – Meat birds (60% DM)	0.15	0.25	0.30	
Sub-total:	2.04-2.40	3.34-3.94	4.34-5.10	1.17
'Wet' materials				
Poultry manure – egg laying flock (30% DM)	0.03-0.06	0.04-0.08	0.05-0.10	
Dairy cattle slurry (10% DM)	0.15-0.16	0.19-0.20	0.24-0.26	
Pig manures (10% DM)	0.04	0.05	0.06	
Food waste (3)	0.09-0.16	0.14-0.26	0.19-0.33	0.71
Sub-total:	0.31-0.42	0.42-0.59	0.54-0.75	0.71
Total:	2.35-2.82	3.76-4.53	4.88-5.85	1.88

Data supplied by D.Turley, Central Science Laboratory except (3) provided by James Vause Defra.

1) Carbon emission factors of 430 t CO_2/GWh used for grid electricity (DTI) and 250t CO_2/GWh (heat) for heating oil (Carbon Trust). For all biomass resources no net emission during production assumed.

Annex C

Table 3 Estimated technical potential of biomass energy sources and for energy crop production (TWh of primary energy)

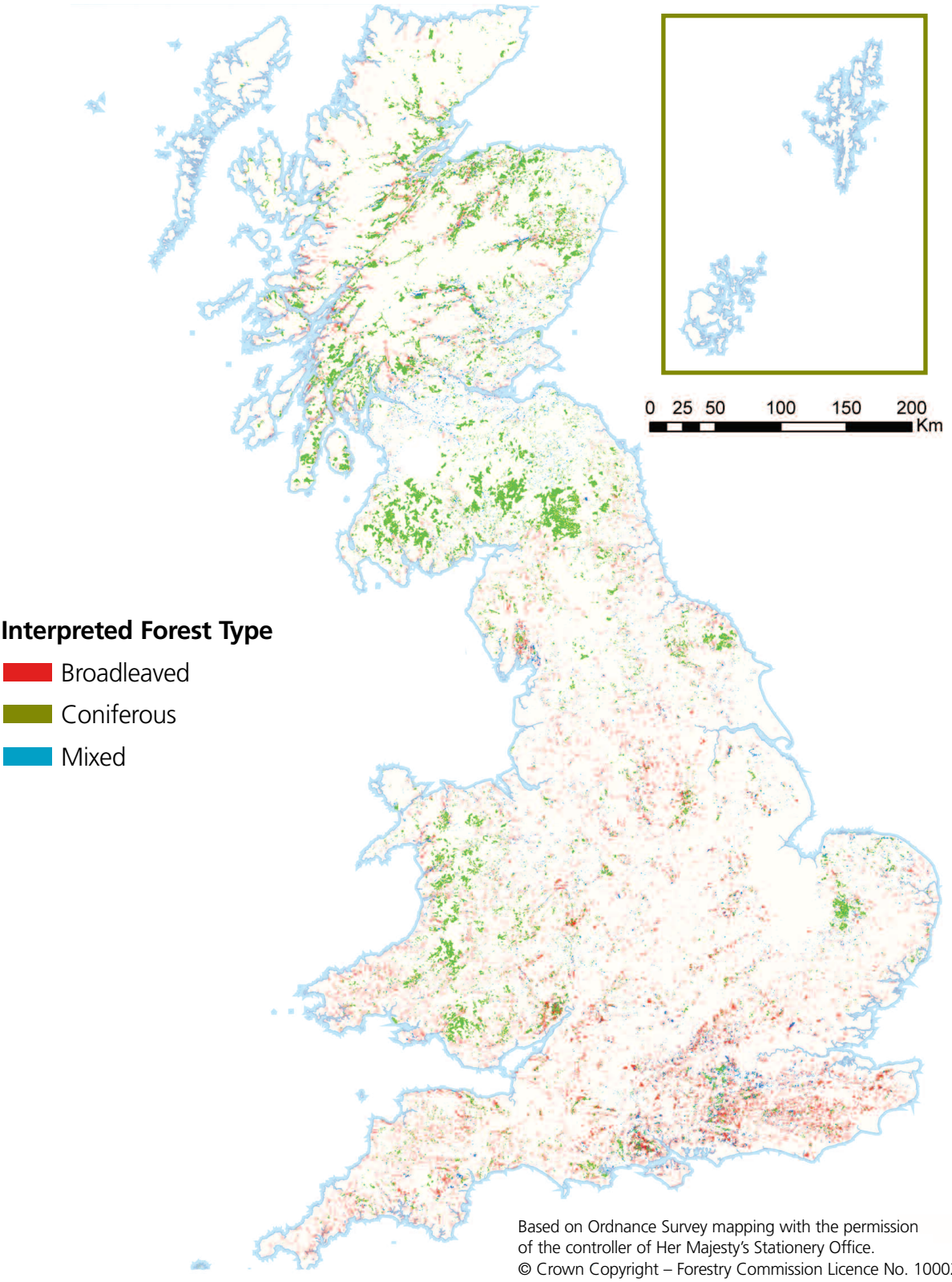
Region	Forest Woodfuel	Straw	Wood Waste	Waste	Agricultural Waste	Energy Crops	Total
Total for UK	13.0	14.5	26.0	15.5	10.0	17.2	96.2

Notes

1. Estimates for woodfuel include forest wood fuel, arboriculture arisings and sawmill co-product, and are taken from recently up dated estimates produced by the Forestry Commission. This includes an additional 2Mt/yr (green – equivalent to ~1Modt/yr) that FC estimates can be obtained from under-managed forestry in England.
2. The values for Energy Crops are only intended to be indicative for a range of options (e.g. SRC, miscanthus, canary grass, eucalyptus) but have been estimated using data for SRC and assume planting on 350,000ha (~6.5%) of arable and set aside land with an average annual yield of 9odt/ha.
3. It is estimated that 3Mt/yr of cereal straw can be used for biomass without affecting existing markets.
4. Values for waste wood are based on a total UK availability of 5.6Mt/yr and include both clean and contaminated material (Defra Waste Strategy 2007).
5. The value for waste includes the proportion of biodegradable UK MSW and Commercial and Industrial (C&I) Wastes that is considered more suited for energy production rather than for other recovery or recycling (Defra Waste Strategy 2007).
6. Agricultural waste includes readily collectible sources of manure, including poultry manure, cattle slurry and pig manures, and represents total annual production during the housing period.

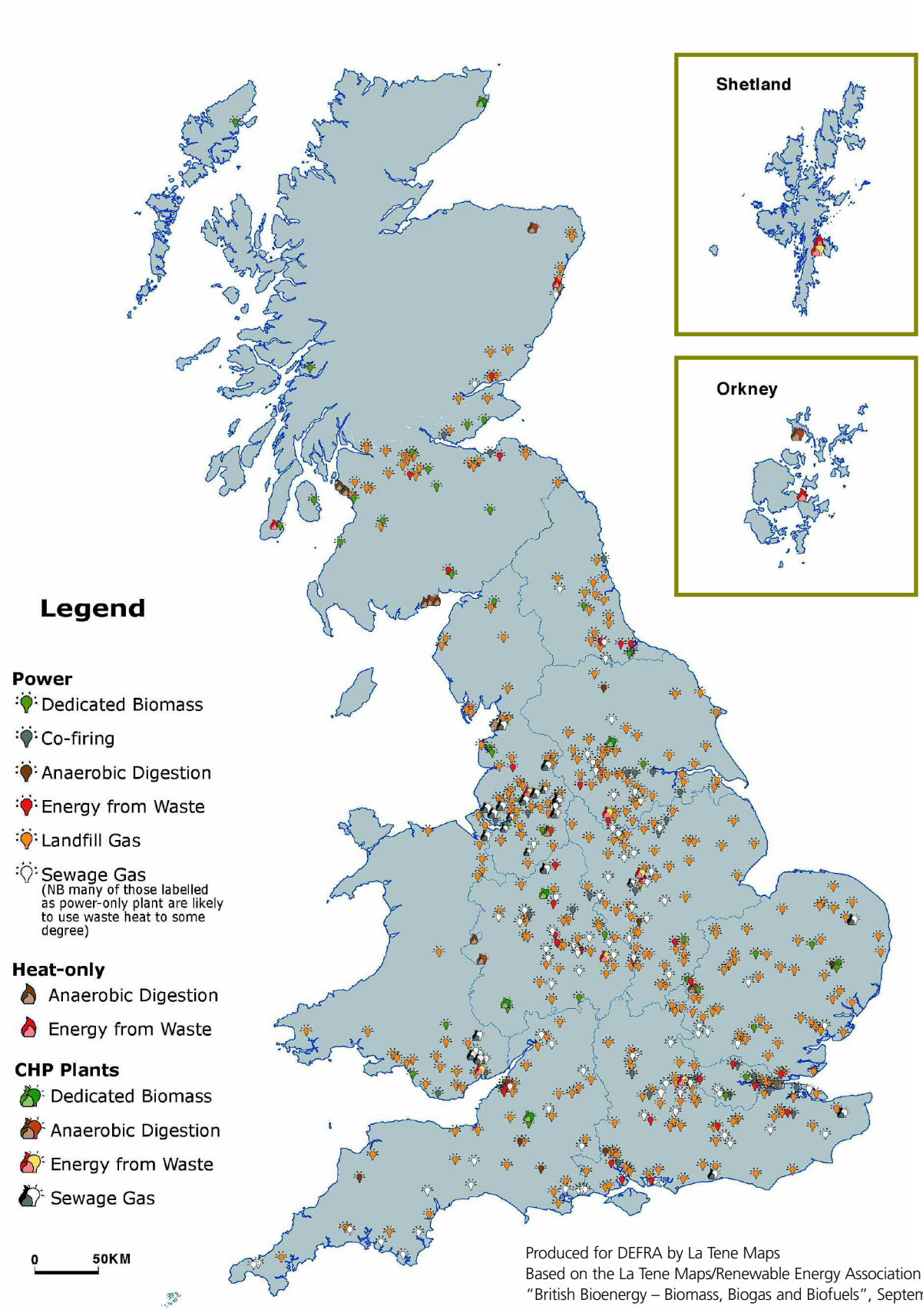
Annex D

Map showing distribution of forest types



Annex E

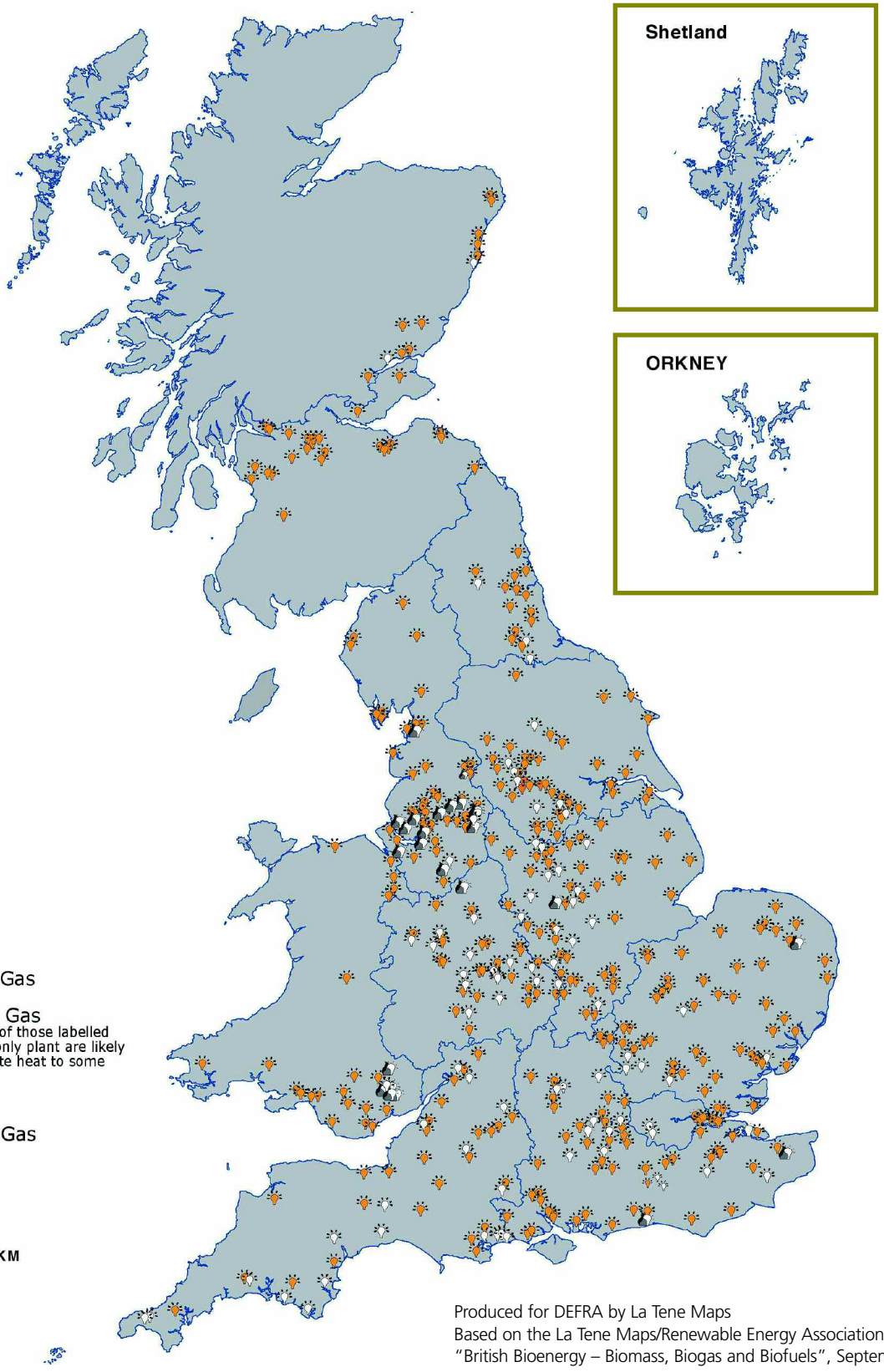
Location of Power Heat and CHP Installations



Produced for DEFRA by La Tene Maps
Based on the La Tene Maps/Renewable Energy Association Map
"British Bioenergy – Biomass, Biogas and Biofuels", September 2006

Annex F

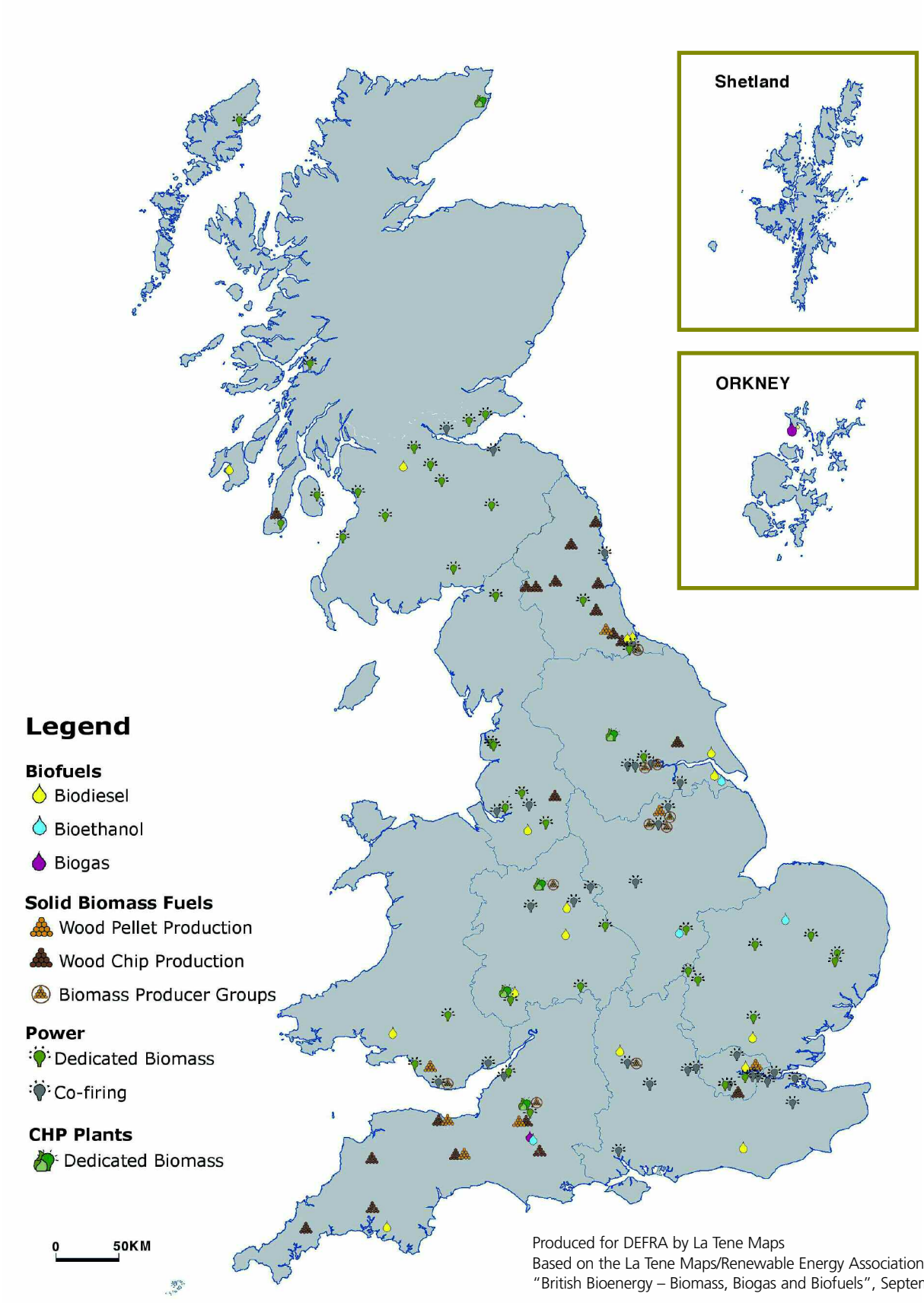
Landfill Gas and Sewage Gas Installations



Produced for DEFRA by La Tene Maps
Based on the La Tene Maps/Renewable Energy Association Map
"British Bioenergy – Biomass, Biogas and Biofuels", September 2006

Annex G

Location of Biofuels and Solid Biomass Installations



Produced for DEFRA by La Tene Maps
Based on the La Tene Maps/Renewable Energy Association Map
"British Bioenergy – Biomass, Biogas and Biofuels", September 2006

Glossary

Anaerobic digestion – involves harnessing the natural process whereby organic matter is broken down by bacteria in the absence of oxygen. The materials ferment in a closed vessel and produce a biogas which is a mixture of about 60% methane and 40% carbon dioxide.

Bio-economy – The bio-economy, a new concept, encompasses many economic activities, each benefiting from new discoveries, and related products and services arising out of the biosciences. The "bio-economy" is defined as that part of economic activities "which captures the latent value in biological processes and renewable bioresources to produce improved health and sustainable growth and development (source – OECD (2005) The Bio-economy in 2030: A Policy Agenda).

Bioenergy – 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 as bioenergy.

Biomass Task Force – Established by Government in October 2004, led by Sir Ben Gill, the Task Force reported to Government in October 2005 with 42 recommendations for addressing current barriers to optimising biomass use for energy generation and carbon saving.

Carbon Trust – is a not-for-profit organisation set up by government with support from business to encourage and promote the development of low carbon technologies. Key to this aim is its support for UK businesses in reducing carbon emissions though funding, supporting technological innovation and by encouraging more efficient working practices.

Clean Air Act 1993 – prohibits the emission of dark smoke from chimneys including domestic premises. It dates from 1956 when it was enacted in response to incidents such as the great London smog of 1952. The 1993 Act consolidates previous changes and amendments.

Climate Change Programme Review (CCPR) – Published by Government in March 2006 (http://www.defra.gov.uk/environment/climatechange/uk/ukccp/index.htm)

Combined Heat and Power (CHP) – CHP is a highly fuel-efficient process that utilises the waste heat produced as a by-product of electricity generation. It is, therefore, more efficient than conventional forms of generation, and can be applied across a whole range of technologies and fuels.

Co-firing – Co-firing refers to the simultaneous combustion of a supplementary fuel (i.e. biomass) with a base fuel (i.e. coal). Co-firing biomass with coal is seen as the cheapest way of generating green power in utility plants. In addition, it also reduces the emissions of fossil based carbon dioxide and is supported under the Renewables Obligation.

Energy Efficiency Commitment – requires electricity and gas suppliers to achieve targets for the promotion of improvements in domestic energy efficiency.

Energy Saving Trust – is a not-for-profit organisation set up and largely funded by government to cut carbon emissions by promoting the sustainable and efficient use of energy in households, small businesses, the public sector and the transport sector.

Eutrophicated – depletion of oxygen in water – the process by which a body of water becomes rich in dissolved nutrients from fertilisers or sewage, thereby encouraging the growth and decomposition of oxygen-depleting plant life and resulting in harm to other organisms.

GWh – GigaWatt Hour.

Mtoe – Million tonnes of oil equivalent.

Non-Food Crops Strategy – published jointly by Defra and DTI in November 2004 to provide a framework for creating renewable materials aimed at increasing commercial opportunities, stimulating innovation, cutting waste and environmental damage, and protecting precious natural resources. A two year progress report on the Strategy was published in November 2006. A Government response, including a refocused action plan for developing the strategy up to the end of 2009, has been published.

PAH – Polycyclic Aromatic Hydrocarbons.

RDPE – Rural Development Programme for England.

Regional Development Agencies (RDAs) – aim to co-ordinate regional economic development and regeneration, enable the English regions to improve their relative competitiveness and reduce the imbalances that exist within and between regions.

Renewables Obligation (RO) – the obligation placed on electricity suppliers to deliver a stated proportion of their electricity from eligible renewable energy sources.

Renewables Obligation Certificates (ROCs) – Companies can meet their obligation by: presenting Renewable Obligation Certificates (ROCs). ROCs are issued to renewable generators for each 1MWh of electricity generated, these are then bought by supply companies. Suppliers can also meet their obligation by paying a buy-out fund contribution per MWh or a combination of the two. Money from the buy-out fund is recycled pro-rata to companies presenting ROCs, hence the value of a ROC = buy-out price + money recycled from buy-out fund. The recycling mechanism gives suppliers an additional incentive to invest in renewables and acquire ROCs.

Renewable Transport Fuel Obligation (RTFO) – The RTFO will, from April 2008, place an obligation on fuel suppliers to ensure that a certain percentage of their aggregate sales is made up of biofuels. The effect of this will be to require 5% of all UK fuel sold on UK forecourts to come from a renewable source by 2010. The RTFO will be one of the main policy instruments in the transport sector to reduce greenhouse gas emissions and increase the use of renewable fuels, helping to meet UK and international climate change objectives as well as contributing to other Government objectives, including security of energy supply.

Solid Recovered Fuel (SRF) – are fuels prepared from non-hazardous waste to be utilised for energy recovery in waste incineration or co-firing plants regulated under Community environmental legislation.

UK Energy Review – Published July 2006 (www.dti.gov.uk/files/file31890.pdf).

Waste Strategy – will be published shortly and will set out the Government's strategy on waste.

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