Imperial College

OF SCIENCE, TECHNOLOGY AND MEDICINE

INTERNATIONAL ENERGY AGENCY (IEA) BIOENERGY TASK40 ON:

‘Sustainable International BioEnergy Trade:

Securing supply and demand’

Country Report for United Kingdom

Report prepared by:
The Bioenergy Group (BEG)
Imperial College London
Centre for Energy Policy and Technology (ICEPT)

Frank Rosillo-Calle & Miles Perry

Report T40UK01R

September 2006

Executive Summary

The Role of Task 40

Task 40 was established by the International Energy Agency (IEA) in December 2003 with the aim of focusing on international biotrade and its wider implications[1]. Bioenergy trade (biotrade) has expanded rapidly in recent years. Forestry and agricultural residues, wood chips, pellets and briquettes for use in co-firing and green power, and bioethanol and biodiesel for transport, are all now traded at significant scales in national, regional and global energy markets[2]. The future vision for global biotrade is that it will develop into a "global commodity market" which will secure supply and demand in a sustainable way. The driving force behind the expansion in bioenergy is the potential it holds in providing an affordable and practical renewable source of energy for climate change mitigation, energy security, and rural development.

In order to initiate the development of the framework for the sustainable provision of biomass for energy globally, Task40 has outlined key short-term objectives as follows:

- Provide information, modelling tools, environmental impact analyses etc. for evaluating biomass markets at different levels.
- Evaluate the factors influencing the supply and demand of biomass for energy.
- Investigate biotrade and exchange national experiences.
- Identify strategies to overcome biotrade barriers.
- Assess sustainability criteria for biotrade and provide "best practice guidelines".
- Increase public awareness of international biotrade.

The role of UK Task 40

UK became a full Member of IEA Task 40 on 1st January 2006[3]. During the last Task 40 meeting[4] it was agreed that an immediate assignment for UK Task40 was to deliver the UK Country Report. The UK is increasingly dependent on energy imports as North Sea oil and gas reserves are running out. Bioenergy remains one of the key components for the provision of low carbon energy in the transport, electricity and heat sectors. The key national instruments for incentivising these bioenergy markets are either in place or under active development e.g. the Renewables Obligation (RO) and the proposed Renewable Transport Fuels and Heat Obligations. Biomass is likely to be the major potential source of low carbon energy in the UK; this role has been further reinforced by the Energy Review[5] which proposes to increase the use of RE. However, given its limited indigenous potential, a significant share may need to be secured through sustainable and reliable imports. Areas of particular interest for biotrade in the UK

---

[1] For further details of Task 40 objectives, visit www.bioenergytarde.org

[2] For example, rough estimates from FAOSTAT show that in 2001-02 about 1.35 Mt of charcoal, 26.7 M m3 of wood chops and particles, 1.93 M m3 of fuelwood and 6.30 M m3 of wood residues were traded internationally (B. Hillring, Dept of Bioenergy, Swedish Univ. of Agric. Sciences, Uppsala, Sweden)

[3] UK Task 40 has received some financial support from the DTI, DEFRA, Dept of Transport (DfT), Czarnikow Sugar, Drax Power and Wessex Grain, to whom we extend our gratitude.

[4] The meeting took place in Trondheim, Norway, 3 - 4 April 2006.

5 The Energy Review was published on 11 July 2006 (see DTI 2006d)

include biodiesel and bioethanol for transport and woody biomass and crop residues for CHP and co-firing. The emerging nature of the markets for these forms of biomass means that a high degree of volatility and uncertainty can be expected in both prices and security of supply (volume, quality and environmental provenance).

The aim of the UK Country Report is to:

- Present a brief overview of the UK energy sector
- Assess the role of renewable energy (RE), particularly bioenergy
- Assess the market potential for biofuels
- Assess the potential for international biotrade

The UK Scene

Due to the UK's unique position as net exporter of energy in the past few decades, energy from renewable sources have not been regarded by successive governments as a high policy priority, compared to most other EU Member States. A recent feature has been a strong shift in support of RE which is beginning to be felt e.g. in 2005 RE provided 4.14% of electricity generated in the UK (16,919 GWh), compared to 3.58% in 2004[6]. A major factor in this increase has been the emergence of co-firing of biomass with fossil fuels, primarily coal, on a large scale. This grew by approximately 150% from 2004, producing 2,533 GWh in 2005 (1,022 in 2004). Overall, the past decade has seen a rapid increase in the use of RE sources for heat and power, from 1Mtoe in 1990 to 3.7 Mtoe in 2004 and 4.25 Mtoe in 2005, of which biofuels other than sewage sludge, landfill gas and municipal solid waste contributed 34% (1.5 Mtoe), or 30% of all electricity generated from renewable sources; still its contribution to the overall energy balance in the UK remains small.

Policy Setting

The overall goals of UK energy policy up to 2050 are set out in the Energy White Paper of 2003 (DTI, 2003), and are described in some details in Sect.3 of the report. The overall objective is "to put the UK on a path to cutting CO_2 emissions by some 60% by about 2050, with real progress by 2020".

These objectives seem to have been reconfirmed by the Energy Review (see DTI 2006d). The most salient features, with regard to RE and potential implications for international biotrade, are its recommendation to increase the share of renewables in electricity supplied from 15% to 20% and in transport fuels from 5% to 10% in 2010 and 2015 respectively. The most promising outcome seems to be the potential impact on co-firing, as discussed in Section 5.

Co-firing was included as a ROC-eligible source of electricity when the RO was introduced. It was intended as a "transitional technology" (DTI, 2006d) to encourage the development of biomass supply chains and energy crop production. The inclusion of co-firing made the combustion of biomass economically attractive in the short term. The

---

6 Figures given are % of electricity generated from renewable sources according to the methodology of the EU Renewables Directive. See DTI, 2006e pp. 168-169

2006 Energy Review (DTI, 2006d), appears to have thrown some light into co-firing when it states: "co-firing should be encouraged to play a long-term role in reducing carbon emissions" (p. 103). This means that it will continue to receive some support under the RO. One proposal from the Energy Review is that the existing limit on the amount of co-firing that is ROC-eligible[7] be abolished and replaced with a banded system where co-firing receives less ROCs / MWh than more desirable forms of renewable electricity.

Bioenergy potential versus supply

The bioenergy potential in the UK is detailed in Sect. 4. The estimated potential (all sources available for energy) is approx. 20 Mt (dt) for energy generation, which although significant, is insufficient to supply potential demand.

Since 2004, after decades of being a net exporter of energy, the UK has become a net importer and this has had major policy implications e.g. strong policy shift toward the use of renewable energy sources, as explained in this report. Still, fossil fuels continue to provide the bulk of primary energy in the UK. For example, petroleum represented about 47% and 43.3% of final energy consumption in 1970 and 2004, respectively (44% in 2005); while coal saw its role reduced significantly, from 20.4% to 1.3% over the same period (1% in 2005). The biggest jump corresponds to natural gas whose consumption increased from 2.5% in 1970 to 34.8% in 2004 (34.3% in 2005). By sector, the main consumption of primary fuels is from the transport sector with 33% of consumption in 2004 followed by the domestic sector with 28%.

The most contentious area relates to energy crops as the gap between targets and actual achievements is very large indeed. For example, the target for short rotation coppice (SRC) was to plant 16,700 ha and 5,000 ha of miscanthus, producing 215,000 and 64,000 odt/year respectively. By the end of July 2006, when the scheme closed to applications, only 1,160 ha of SRC and 3,370 ha of miscanthus had been planted[8]. Interest in planting bioenergy crops has increased in the last two years and applications to plant in 2007 suggest that a further 15,000 ha, mostly of miscanthus, may be planted.

Heat market

This market accounts for approximately 30% of the bioenergy consumed in the UK, representing about 0.5 Mtoe of which 94% (470,000 toe) are biomass. An interesting feature is that there are currently 4.42 million unconnected dwellings to the main gas grid in the UK which represent a technical potential market of nearly 79 TWh/yr; the technical potential for all sectors is estimated at about 180 TWh/yr, compared to a current production of 6.31 TWh/yr.

The heat market is very attractive firstly for its size and secondly for its competitiveness with natural gas e.g. 1.5 pence/kWh for pellets compared to 2.34 pence/kWh for natural gas. It is expected that this market will largely be supplied domestically rather than by

---

[7] The possible impacts of the Energy Review on co-firing are still unclear. It is hoped that further details will be provided in the on-going report on co-firing

[8] Personal communication with DEFRA, 2006

imports given that the majority of applications are small-scale. It would require the development of a good production and supply infrastructure. Traditionally, UK lacked experience in the production of pellets, as shown in this report.

Biomass CHP

In 2004, total inputs of RE fuels into CHP were 2,744 GWh, or 2.2% of total energy inputs into CHP. Most of the raw material use consists of waste products such as landfill gas, sewage gas and municipal waste. Current policies do not provide any specific support for biomass CHP, though some plants do qualify for other support measures such as capital grants. Most biomass CHP schemes are relatively unattractive compared to biomass heat-only facilities because of additional cost of capital. The rate of return on investment for operating a heat-led CHP scheme was estimated to be 5.4% compared with over 21% for a heat-led plant. However, the competitiveness of CHP improves when the ROC-value of the electricity is taken into account. At present, there are various biomass CHP plants operating in the UK, though their aggregate contribution to the energy sector is small (see Sect.4.3).

Co-firing market

This is the most important market for biotrade and has been, as indicated above, the fastest growing biofuel market in the UK, which in 2005 generated 2.5TWh electricity, representing an increase of 148% over the previous year. There has been serious concern with the long term future of this market. It seems that the Energy Review has brightened up its long term future (see Section 5). However, many details are still unclear. Co-firing represents the most promising alternative for large scale use of biomass if the right policy is put in place.

Currently there is little long-term reliable data on biomass feedstock used in co-firing. In 2005 the majority of feedstock was imported (see Fig. 6). Replacing the current quantitative restrictions with a system of banded ROCs could potentially restore the opportunity for operators to import favourably-priced biomass feedstocks as a marginal, ROC-creating activity. Even, if a new policy regime were to give preference to local energy crops, this would affect the price competitiveness of the imported feedstocks rather than restricting their absolute quantity.

Transport Sector

This could be, potentially, a large market for biotrade since the UK will require large amounts of biodiesel and bioethanol which is highly unlikely to be supplied domestically, either because of high costs or domestic supply limitations. The main policy for encouraging liquid biofuels in the UK market has been a fuel duty incentive, introduced in 2002 for biodiesel and in 2005 for bioethanol. The incentive consists of 20 pence/litre discount on fuel duty compared to ultra-low sulphur petrol or diesel. The incentive is guaranteed until 2009. The current government target is to blend 5% (v/v) by 2010 and 10% by 2015.

At present the production of biofuels in the UK is very small e.g. in 2005 the total biofuel sales accounted for a mere 0.18% of total fuel sales by energy content (DfT, 2006). Biodiesel is sold in 138 filling stations (5% ethanol blend) plus a further 11 that sell E85; there are also 185 filling stations selling bioethanol. In 2005, 85 million litres of bioethanol were imported for use in road transport in 2005, representing 0.17% of total fuel sales by volume (DfT, 2006). With the new target of 10% by 2015, this market is bound for a large expansion which, most probably, would have to be satisfied to a large extent by imports. In the current RTFO legislation, bioethanol and biodiesel are specified as the only two fuels that qualify towards suppliers' renewable fuels obligation. However, several other forms of biofuel are also being explored.

Prospects for international biotrade

It is difficult to obtain detailed reliable information concerning the level of bioenergy imports into the UK. There are two main difficulties: i) reluctance of suppliers and consumers to provide data as this is often regarded as commercially sensitive, and ii) difficulties with statistical classification as most imports are not necessarily classified as energy. This is a common feature throughout the whole industry, and thus far from being unique to the UK market.

Much of the material imported is for co-firing or use in any densified form. It is difficult to determine trade patterns for co-firing since imported feedstocks are typically purchased on spot markets and operators have the ability to switch between different suppliers and different feedstocks to pursue best value for money. A variety of feedstocks can also be used for the manufacture of pellets, providing the pellets meet stated specifications in terms of size, heat and moisture content.

The UK is a nascent producer and consumer of many forms of bioenergy. This means that trade in bioenergy exists for products consumed for energy in the UK which are not yet produced domestically. As indicated in the Strategic Advice[9] international biotrade faces a large number of barriers and the situation in the UK is not necessarily much different. A particular feature of the UK market is the willingness to trade internationally, as free market is a fundamental philosophical tenet when compared with many other countries.

One of the most difficult barriers in the UK has been obtaining planning permission to build new power plants, of any kind. The Energy Review pays particular attention to this issue and intends to sweep away many of barriers that impede or hamper the introduction of RE including biomass.

Certification

Certification is unlikely to solve social, economic, environmental, and sustainability problems posed by land use, resources, etc as currently most (or none) of the schemes are not an effective substitute for positive governmental legislation. In addition, if certification schemes are not easily and effectively implemented, they can hinder rather

---

[9] See Task 40 website www.bioenergytrade.org for details of the Strategic Advice document

than enhance international biotrade. However, in the longer term if some kind of rules that satisfy the wider international audience can be agreed, certification can play an important role in promoting sustainable international biotrade.

TABLE OF CONTENTS

1. Introduction

The information gathered in this report is largely based on existing statistics, reports and personal communications. This report presents an overview of the energy sector in the UK, with particular attention to bioenergy potential (heat, CHP, co-firing and transport applications); it examines the main policies introduced to support RE; market potential and international biotrade.

1.1 General Country Characteristics

The UK had a population of approximately 60.2 million people in mid-2005. The population of the UK has grown in the past decades and the rate of growth has increased in recent years, from an average of 0.3% growth per year between 1991 and 2004 to 0.5% annual growth since 2001 (ONS, 2006). In 2004, UK GDP per capita was the 6th highest in the EU-25, in terms of purchasing power standard (Eurostat, 2005). The land area of the UK is 247,193 km^2, giving a population density of 240 people per km^2, the fourth highest in the OECD (BBC, 2006).

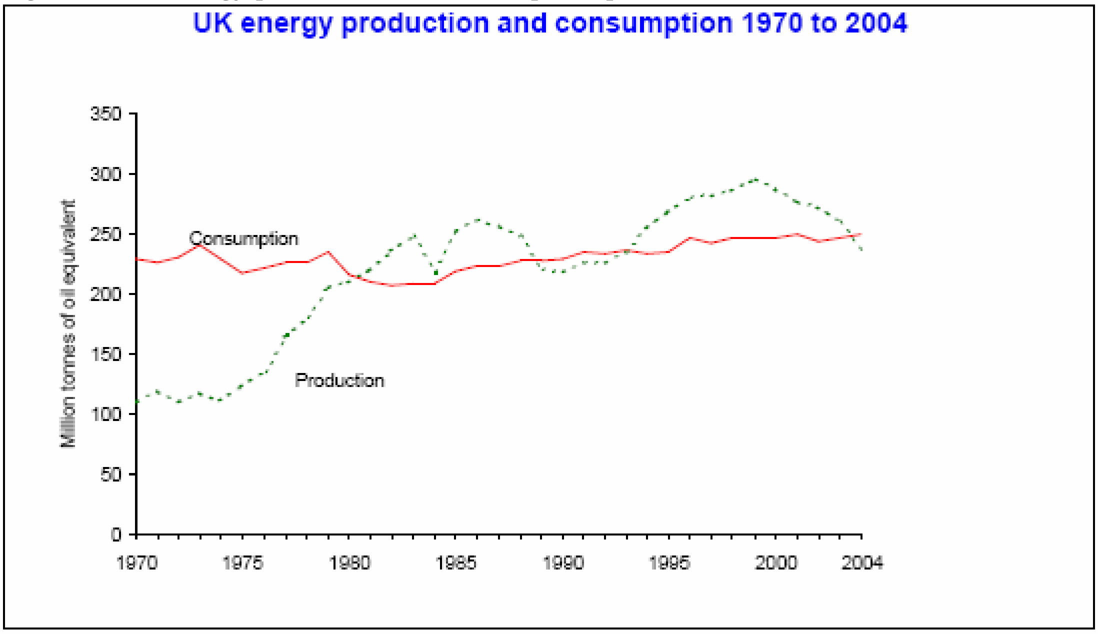
2. Overview of UK Energy Sector

In 2004, the UK's energy intensity ratio, a measure of energy consumed per unit of GDP, stood at 207 kgoe/'000€ (Eurostat, 2006). This was the seventh lowest ratio in the EU-25 and 49% lower than the same measure in 1970 (DTI, 2005). As in most developed economies, the energy intensity of the UK has fallen steadily over the past 30 years.

2.1 Energy Consumption

Over the past 30 years, the UK has switched from being a net exporter to becoming a net importer of primary energy. As Figure 1 shows, the UK became a net importer in 2004, importing about 5% of consumption. Production of North Sea oil and gas peaked at levels of 150.2 Mtoe and 108.4 Mtoe in 1999 and 2000 respectively

Figure 1: UK Energy production and consumption, period 1970 to 2004.



(Source: DTI 2005)

This period also saw a shift from coal to gas as the main source of primary energy, and towards greater use of gas and electricity in the final consumption sector. As Table 1 shows, natural gas accounted for 41% of primary fuel consumption for energy use in 2004 compared to 5.4% in 1970. At the same time, the use of coal as a primary fuel fell from 47.1% of total use to 16.7%. A similar switch from coal to gas also occurred among final users, accompanied by an increase in the proportion of final energy consumed as electricity from 11.3% to 18.2%.

Table 1: UK Primary energy consumption by fuel, 1970 – 2004

	Energy consumption by final user (1)		**Inland consumption of primary fuels for energy use**	
	1970	2004	1970	2004
	%	%	%	%
Coal	20.4	1.3	47.1	16.7
Coke and Breeze	8.9	0.4	-	-
Other Solid Fuels	1.5	0.2	-	-
Coke Oven Gas	0.8	0.0	-	-
Natural Gas	2.5	34.8	5.4	40.9
Town Gas	7.4	0.0	-	-
Electricity	11.3	18.2	-	-
Nuclear electricity	-	-	3.3	7.8
Hydro electricity	-	-	0.2	0.3
Net electricity imports	-	-	-	0.3
Heat Sold (2)	-	1.4	-	-
Renewables (1)	-	0.5	-	1.5
Petroleum	46.9	43.3	44.0	32.6
Total (Mtoe)	**145.6**	**161.0**	**210.1**	**234.9**

(1) Consumption by final user is net of fuel industry's own use and losses from conversion, transmission and distribution
(2) Inland consumption figure relates to renewables and waste
(3) Heat (or steam) that is produced and sold under the provision of a contract. Heat sold is derived from heat generated by Combined Heat and Power (CHP) plants and from community heating schemes without CHP plants.

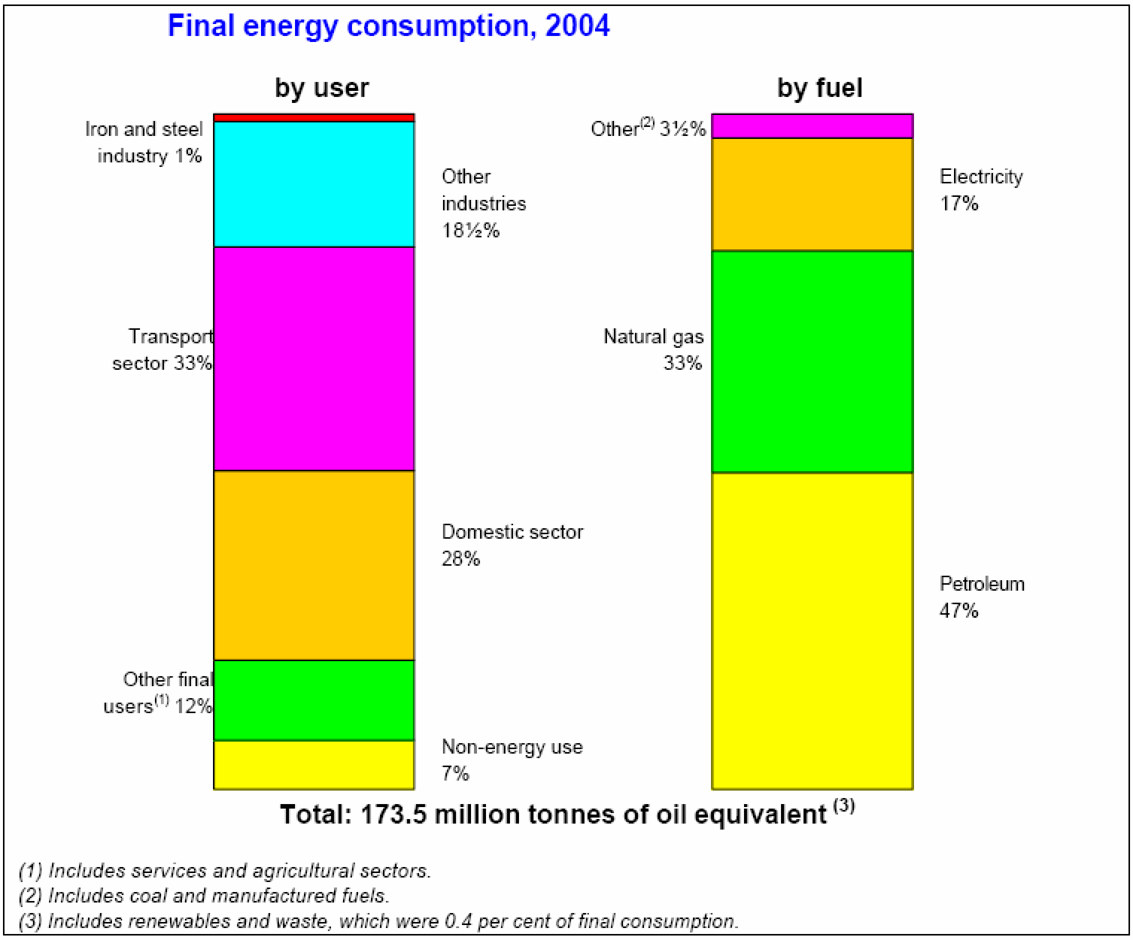
(Source: DTI 2005)

2.2 Main consumers of energy

The main consumer of energy in the UK, as Fig. 2 shows, is the transport sector followed by the domestic and industrial sectors. In 1970, 42% of energy consumption came from industry. However, since 1986 the industrial share of final energy consumption has been smaller than that of both the domestic and transport sectors.

The largest consumers in the industrial sector are the chemical industries (accounting for 18.5% of industrial final energy consumption) followed by metal products, machinery and equipment (11.5%), food beverages and tobacco (11.5%), iron and steel and non-ferrous metals (8.5%) and paper and publishing (7.5%).

Figure 2[10]: Final energy consumption in the UK by user and fuel in 2004



(Source, DTI 2005)

2.3 Electricity production

The above-mentioned increase in the use of gas as a primary fuel is partly due to its increase use in electricity generation over the 1990s, the so-called *dash for gas*. In 1990, electricity generation accounted for 1% of UK natural gas consumption. By 2004 this had risen to 30%. The use of gas for electricity generation has slowed in recent years as gas prices have risen considerably. In 2005, compared to 2004, 5.7% less gas was used for electricity generation and 29% of gas demand was from the electricity industry (DTI, 2006).

The UK electricity sector is dominated by coal, gas and nuclear sources. In 2005, total electricity supplied to the UK was 379 TWh, of which 39% came from gas, 34% from coal and 19% from nuclear. In the same year, 3.3% of electricity generation came from renewable sources in the UK (including large-scale hydro, which is not eligible for the Renewables Obligation) (DTI, 2006e, see Table 5.6).

---

[10] Total Consumption of 173.5 Mtoe includes total non-energy use of fuels of 12.5 Mtoe. This accounts for the difference in consumption between Table 1 and Chart 2.

2.4 Heat and Combined Heat and Power (CHP)

The UK residential sector is estimated to have a total demand for space and water heating of 452 TWh/year (Future Energy Solutions (FES), 2005). There are approximately 25 million dwellings in the UK, 250,000 of which are connected to district heating systems. In addition, there are 175,000 people resident in multi-occupancy facilities such as nursing homes and student accommodation (DETR, 1998).

By the end of 2004, there were 1,552 Combined Heat and Power (CHP) plants operating in the UK, with a total operating capacity of up to 5,606 MWe. This is compared to 1,320 schemes (4,777 MWe) in 1996. Though electricity generation through CHP has expanded over the past decade, the economic viability of CHP schemes is greatly influenced by the relative prices of gas and electricity. The electricity price determines how much a scheme can realise for its product while the gas price (in most cases) determines the cost of its fuel. As Figure 3 (a&b) shows, from 2000-2003, gas prices for domestic and industrial users rose while electricity prices continued their long-term decline. This created less favourable conditions for CHP and led to a total increase in CHP capacity of only 47 MWe from 2000 to the end of 2003 and the closure of some CHP schemes.

Figure 3 (a)

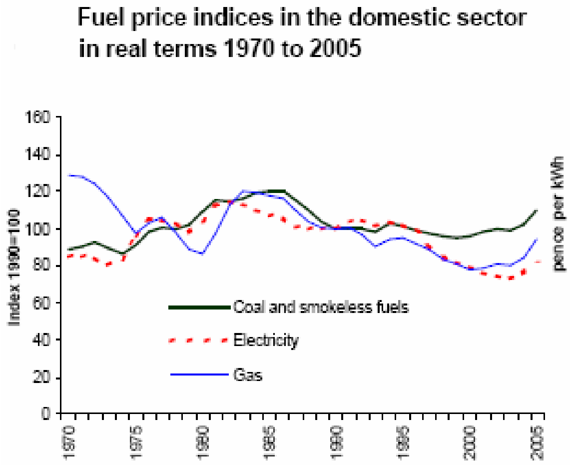
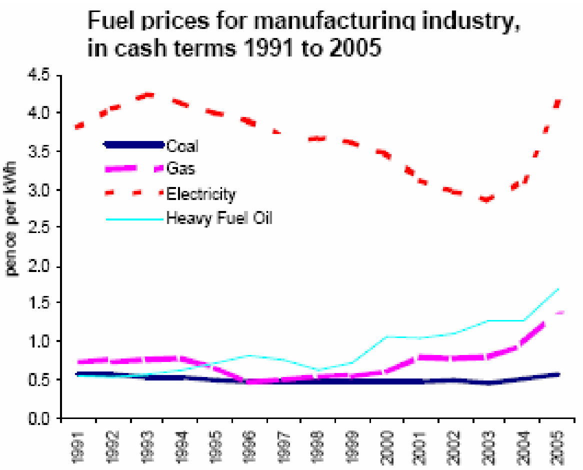


Figure 3(b)



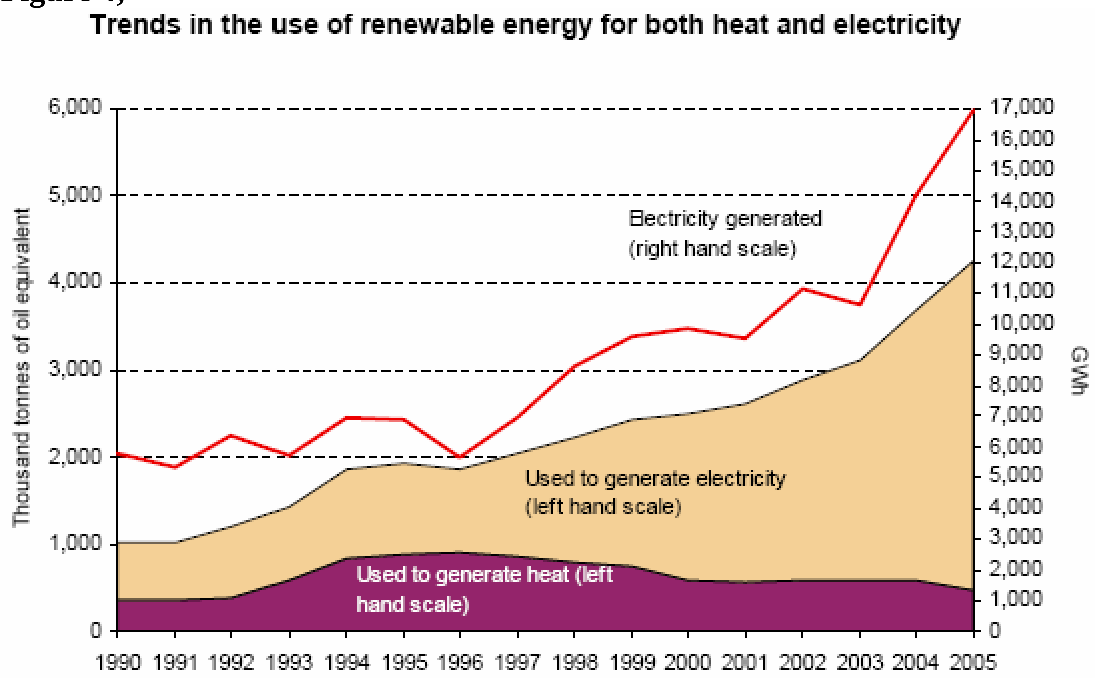
(Source: DTI, 2006b)

As in the electricity sector, the UK CHP sector switched from coal towards gas in the 1990s e.g. in 1996 coal accounted for 16% of the fuel energy used in CHP. This had fallen to 5.6% by 2004. Over the same period, use of gas had doubled, accounting for 64.8% of the fuel input, compared to 38.5% in 1996. This shift was not accompanied by a substantial increase in the use of renewables. Renewable fuels accounted for 2.1% of input into CHP in 2004. This consisted mainly of sewage gas and municipal waste and refuse-derived fuels.

2.5 Renewables

Figure 4 shows the amount of energy from renewable sources used to generate electricity and heat in the UK since 1990. It includes the primary energy content of combustible fuels (such as biomass and waste-derived fuels) and the electricity or heat produced from wind, hydro and solar sources. The total use of renewable heat and power sources in 2004 was 3.8 Mtoe, a fourfold increase on the 1990 level. Renewable heat use reached a peak of 898 ktoe in 1996 before falling. This is because operators burning biomass for heat were obliged to upgrade their plants to meet stricter emissions controls. For many renewable heat plants this was not economically viable given the falling price of gas. Wood is the largest source of renewable heat in the UK, accounting for 81% of renewable heat (both commercial and domestic) in 1996 and 70% in 2004.

Figure 4;



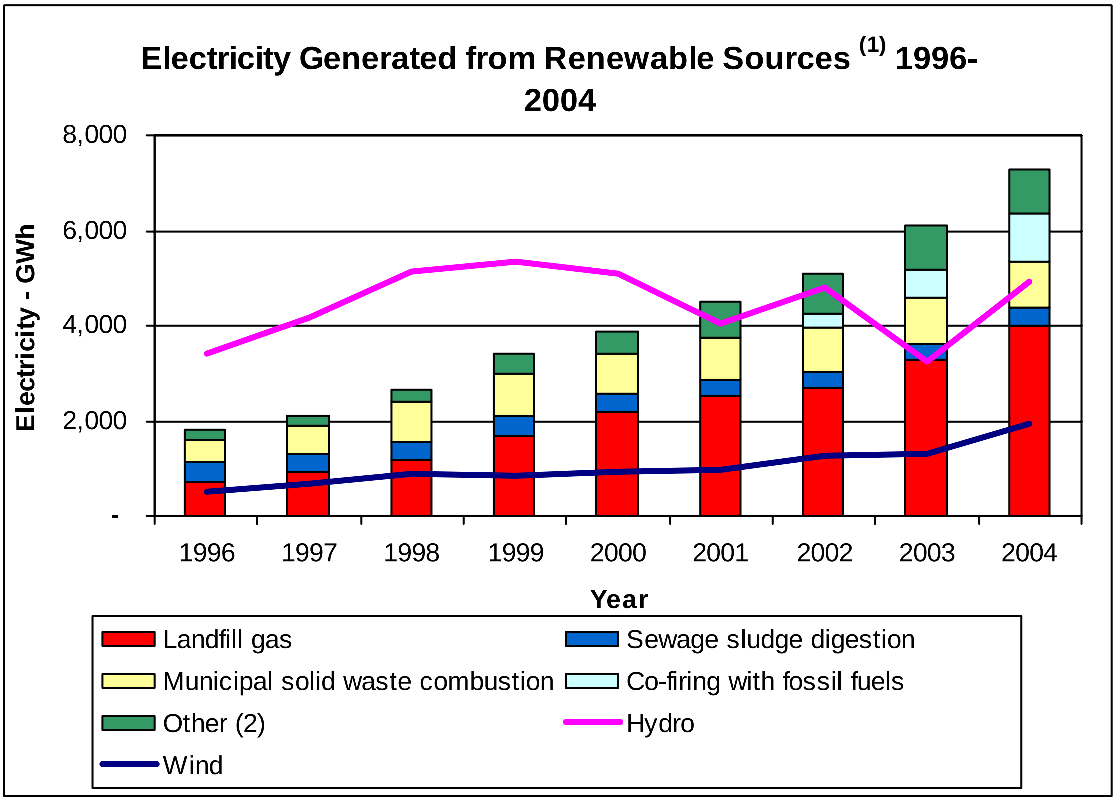
(Source: DTI, 2006b)

Biofuels form the largest source of input energy for renewable electricity in UK, accounting for 81% of renewable energy in 2004[11]. Electricity generated from all biofuels in 2004 was 7.3 TWh. This amounts to 51.5% of total renewable electricity. Biofuels other than landfill gas, sewage sludge and municipal solid waste (MSW) combustion accounted for 1.95 TWh of this, approximately 14% of renewable electricity generation. By 2005, biofuels accounted for 53% of renewable electricity, of which sources other than sewage and refuse accounted for 3.4 Twh or 20% of renewable electricity. The next largest generators were hydro (34.8%) and wind (13.7%). Since 2001, biofuels have replaced hydro as the largest generator of renewable

[11] This figure counts biofuel energy sources as the calorific content of the biomass. Non-combustible energy sources such as hydro, solar and wind are counted as the electricity generated.

electricity. In Figure 5, biofuels are represented by the vertical bars. However, most of these biofuels are waste-derived, the main source being landfill gas. Since 2002, co-firing of biomass with coal has also become a major source of renewable electricity, accounting for 7.2% of total renewable electricity generation[12] in 2004.

Figure 5



(1) Waste material includes only biodegradable element

(2) Other includes straw, short rotation coppice, farm waste digestion and poultry litter, meat and bone combustion

(Source: DTI, 2005)

[12] Co-firing accounts for 7.2% of renewable electricity generation; excluding large-scale hydro, the figure is 10.7%.

3. UK Policies to encourage Renewable Energy

The overall goals of UK energy policy to 2050 are set out in the Energy White Paper of 2003 (DTI, 2003). The first of the White Paper's four main objectives is "to put the UK on a path to cutting CO_2 emissions by some 60% by about 2050, with real progress by 2020" (p. 15). The "real progress" in question is an aim to keep carbon emissions in 2020 15-25 MtC below their predicted business-as-usual level of 135 MtC. This section outlines the policy instruments that have been put in place since the White Paper to meet the 2050 target.

3.1The Renewables Obligation (RO)

The Renewables Obligation is the main policy instrument aimed at boosting the use of renewables in the electricity industry. Its aim is to ensure that 10% of UK electricity is supplied from renewable sources by 2010. This is the UK's contribution to the European Union Renewables Directive that requires 12% of energy (22% of electricity) to be supplied from renewables at EU level).

For each MWh of renewable electricity generated, a tradable ROC (Renewables Obligation Certificate) is issued by OFGEM[13]. From 2002, licensed suppliers of electricity have been obliged under the RO to supply a given percentage of their electricity from renewable sources. They can do this by generating ROC-eligible electricity themselves, by buying ROCs from other generators or paying a buyout price linked to inflation. At the end of the year, the buyout fund – the total value of the buyouts purchased – is redistributed to ROC holders. This provides a further incentive for suppliers to buy or produce ROCs rather than pay the buyout price.

The initial level of RO was 3% in 2002. This rises over time to 15.4% in 2015 with a recent promise by the Government that it will rise to 20% "when justified by growth in renewable generation" (DTI, 2006d, p. 101). The RO is guaranteed to remain in place until at least 2027. This is to provide sufficient confidence to investors that a long-term market exists for renewable energy projects, even those that in the short-term rely on the RO to be economically viable.

A change of focus for the RO was announced in the recently published Energy Review (DTI, 2006d). Initially the review was designed to favour the most economical forms of renewable electricity. It did this by not discriminating between different forms of renewable generation, thereby letting the market decide which renewables to choose. The Energy Review has proposed that, in future, the Obligation be 'banded' so that forms of renewable generation that are more economically viable at present (e.g. co-firing, onshore wind) receive less ROCs per MWh than more experimental forms of generation (e.g. offshore wind, microgeneration).

Table 2 shows the ROCs issued to different renewable sources in the latest compliance period (April 2005 – March 2006). In this period, co-firing is the second largest source

[13] OFGEM is the UK energy regulator, responsible for administering the RO scheme and maintaining the ROC Register

of ROCs and produces almost four times as much electricity as dedicated biomass plants. See Appendix for a breakdown of ROCs issued in the calendar year 2004.

Table 2: Renewable Obligation Certificates (April 2005 – March 2006)

Energy Source	Number of ROCs Issued (1 ROC = 1 MWh)
Biomass	895,480
Biomass and waste using advanced conversion technology	8,938
Co-firing biomass with fossil fuels	3,441,899
Hydro (only schemes under 20 MW are ROC-eligible)	1,918,786
Landfill gas	4,001,010
Micro-hydro (schemes with capacity of less than 1.25 MW)	56,732
Off-shore wind	466,971
On-shore wind	2,574,840
Photovoltaic	40
Sewage gas	320,590
Total	13,685,286

(Source: OFGEM, 2006)

3.2 The Climate Change Levy

Introduced in 2001, the Climate Change Levy (CCL) is a surcharge per unit of energy used in the commercial, industrial and public sectors. The levy is charged for the use of different fuels depending on their energy content. Users must pay 0.43 pence per KWh of electricity consumed, 0.15 p/KWh for gas, 0.96 pence/kg of liquid petroleum gas and 1.17p/kg for solid fuels and fuel commodities.

The intended purpose of the CCL is to provide a fiscally-neutral incentive for organisations to improve their energy efficiency. For this reason, the introduction of the CCL was offset by a 0.3% reduction in employers' National Insurance contributions, reducing the cost to organisations of employing people but increasing the cost of using energy.

There are several exemptions from the CCL. Most importantly, the transport and domestic sectors are exempt – although the transport sector is largely covered by existing excise duties on oil products. Electricity generated from good quality CHP schemes[14] and renewable sources are also exempt (HMRC, 2006).

In addition, the UK government has negotiated a number of Climate Change Agreements (CCAs) for energy-intensive industries. These are individual agreements made between the Department for Environment, Food and Rural Affairs (DEFRA), the trade association of each industrial sector and the participating companies within each sector. Each agreement lasts for 12 years. In this time, the sector must collectively meet its negotiated energy efficiency or emissions target in exchange for an 80% discount on the CCL. Performance against the targets is assessed every two years and companies that fail to meet their targets can be recertified as eligible for the CCL discount by purchasing allowances from other firms.

Box 1: Example of Climate Change Agreement: the Paper Industry

In 2001, 84 facilities signed up to the CCA negotiated between DEFRA and the Paper Federation of Great Britain. The agreement required the sector to limit its Specific Primary Energy Consumption[15] to 4,659 kWh/tonne in 2002, falling to 3,959 kWh/tonne by 2010.

The CCA represents a 36% reduction in energy consumption between 2000 and 2010. The Paper Federation estimate that 1 percentage point of this saving will come from specified changes in the final product mix. This compares to an estimated 14% reduction that would be achieved under Business-as-Usual conditions over the same period and a 37% reduction that would be achieved were the industry to use All Cost Effective (ACE) technology[16].

The CCA is estimated to save 0.43 Mt of carbon in 2010 compared to Business-as-Usual. In the most recent Target Period (2003-04), the sector achieved a saving in excess of its target equivalent to 201 ktCO_2. This savings was ring-fenced (set aside for future use).

(Source: DEFRA, 2001; FES, 2005b)

In the first target period (2001-02) 88% of sectors were recertified as eligible for the CCL discount. In the second period 90% being recertified (FES, 2005b).

3.4 EU ETS – European Union Emissions Trading Scheme

EU ETS is the European Union's major policy developed in order to meet its Greenhouse Gas (GHG) reduction commitments under the Kyoto Protocol. As a whole, the EU is committed to achieving a GHG reduction of 8% compared to 1990 levels by

[14] Good Quality CHP schemes are those that meet the efficiency criteria of the Combined Heat & Power Association Quality Assurance Scheme www.chpqa.com
[15] Specific Energy Consumption is energy consumed per unit of output.
[16] ACE technology assumes the industry adopts all technologies and management practices that are cost effective but assumes that infinite capital and management time are available

2008-2012. Under the Burden Sharing agreement[17], the UK's commitment is a 12.5% reduction on 1990 emissions, though this level of abatement is surpassed by the UK policy targets mentioned above. Each Member State of European Union sets its own National Allocation Plan (NAP) which sets out how the scheme will be managed at national level and how many permits are issued to domestic operators. Each Member State's plan must be approved by the European Commission. Since EU ETS is an EU-wide trading scheme, the actual level emissions and abatement in each Member State can differ from the NAP.

The UK's NAP for the first phase of EU ETS (2005-2007) allocated allowances with a total carbon value of 736.3 $MtCO_2$. 6.3% of this allocation consists of a new entrant reserve so that allowances can be issued to new entrants to the industries covered by the scheme. Over the period in question, the level of allowances issued represents an 8% cut relative to projected emissions from the installations in question. The projection is of emissions that would have been created without EU ETS but with existing government policy measures in place (DEFRA, 2005). By issuing a level of allowances that requires industry as a whole to reduce GHG emissions, EU ETS creates a market in GHG abatement. It also creates a carbon market and carbon price since firms needing to exceed their permitted emissions will need to purchase spare allowances from other firms. This helps the relative viability of bioenergy schemes that represent emissions savings for the large industrial units covered by the scheme. Thus the carbon savings can contribute to the cost effectiveness of measures such as co-firing of biomass in fossil fuel plants or switching to biomass heating in industrial units.

Under the UK NAP first phase, large fossil power stations such as Drax Power[18] and Aberthaw[19] were allocated emissions equivalent to 72% of relevant emissions (a figure based on an installation's average emissions from average emissions from 1998 – 2003). The allowances allocated to power stations as a whole required greater cuts in GHG emissions for power stations than any other. For example, iron and steel plants are permitted to increase their emissions by up to 4.6% (DEFRA, 2005). This was because power stations are thought to have the greatest potential for incorporating emissions control into their operations and because power stations face relatively little competition, either from outside the EU or from other companies not covered under EU ETS.

The extent to which EU ETS constraints act as a factor encouraging the take up of carbon abatement systems such as bioenergy depends on the carbon price, which in turn depends on the total level of carbon abatement demanded by EU ETS as a whole. At present, it is uncertain how the carbon price, and hence the abatement incentive it offers to firms, will develop. This is shown by the volatility in the carbon price. EU ETS allowances began trading at under 10 €/tCO_2 in January 2005, rose to over 30 €/tCO_2 by April 2006 but then fell to under 15 €/tCO_2 at the start of May 2006 (Energy Business Review, 2006).

[17] Council of the European Union Decision 2002/358/EC
[18] http://www.draxpower.com/
[19] See site of RWE NPower, http://www.rwenpower.com

4. UK Potential Biomass Supply

Several studies estimate the primary energy available from the UK's existing forestry resources and waste materials to be approximately 40 TWh/year. This section of the report examines the UK's bioenergy supply, by reviewing studies of the UK's resource potential.

4.1 Potential supply from existing biomass

Table 3 shows a summary of the potential bioenergy from currently available biomass in the UK. The supply of forestry waste and arboricultural arisings takes into account competing demand for some of these products and assumes that only 10% of total small roundwood and sawmill co-product will be made available for woodfuel use (Forestry Contracting Association, 2003). Also, since the MSW figure includes the non-biodegradable component of the waste, the figure given is higher than the amount MSW that can qualify as a renewable energy source[20]. See Appendix for B for estimates of geographical, technical and economic potential biomass resources.

[20] See DTI, 2005

Table 3: Quantification of existing biomass resource and its potential energy generation

Biomass source	Available tonnage (dry tonnes)	Energy contained in biomass (TJ)	Potential energy generation (GWh)	
			Electricity only	Heat only
Conversion Efficiency			30%	85%
Dry Material				
Forestry waste and arboricultural arisings	1,460,000	21,900 - 25,988	1,825 - 2,166	5,171 - 6,136
Waste wood (industrial)	3,000,000	35,700	2,975	8,429
Energy crops (short rotation coppice (willow/poplar) and miscanthus	250,000 - 366,750	3,940 - 6,671	328 - 556	930 - 1,362
Cereal straw (not used for other purposes)	3,000,000	40,500 - 49,500	3,375 - 4,125	9,563 - 11,688
Municipal Solid Waste (includes non biodegradable fraction)	7,600,500	60,804 - 76,005	5,067 - 6,334	14,357 - 17,946
Sewage sludge	384,222	5,802 - 7,684	483 - 640	1,370 - 1,814
Poultry manure - meat birds (60% dry matter)	1,158,300	16,216	1,351	3,829
Sub-total	**16,853,022 - 16,969,722**	**184,862 – 217,764**	**15,404 – 18,147**	**43,649 – 51,204**
Wet material (for anaerobic digestion)				
Conversion efficiency			40%	85%
Poultry Manure - egg laying flock (30% dry matter)	356,700	2,461 - 4,815	270 - 540	580 - 1,140
Dairy cattle slurry (10% dry matter)	2,016,000	11,592 - 12,600	1,290 - 1,400	2,740 - 2,980
Pig manures (10% dry matter)	535,500	2,923 - 3,480	320 - 390	690 – 820
Sub-total	2,907,200	16,976 - 20,895	1,880 - 2,330	4,010 - 4,940
Total	**19,760,222 - 19,876,972**	**201,838 - 238,659**	**17,284 - 20,477**	**47,659 - 56,144**

(Source: Biomass Task Force, 2005)

A separate study by the Carbon Trust (Carbon Trust, 2005) found the potential energy supply from current UK biomass resources to be approximately 41 TWh/year, equivalent to 1.5% of primary energy consumption at the 2003 level. This figure was obtained by analysing the resource chains[21] that are most cost effective and offer the greatest potential carbon abatement. Dry paper, agricultural residues, wet food waste, woody energy crops, waste wood and forestry were chosen as viable resources. Heat and electricity was chosen as the preferred end use (as opposed to transport) due to its greater short-term carbon saving potential. The study also found the amount of available energy could increase to 80 TWh/year if an area of 680,000 ha (equivalent to the UK's set-aside land) was used to grow woody energy crops.

4.2 Measures to encourage cultivation of bioenergy crops

Table 3 shows that only a tiny fraction of the UK's bioenergy resource (at most 2.8%) comes from dedicated energy crops rather than waste materials. At the same time, the Carbon Trust study shows that a substantial expansion in the growth of woody energy crops has the potential to double the supply of biomass for energy. In order to improve the supply of dedicated biomass crops in the UK, the Energy crops Scheme was established by DEFRA. Its aim was to encourage farmers to grow woody energy crops, to work collaboratively and to improve the efficiency of production. The scheme accepted applications until the end of July 2006 and provides the following support measures:

- a planting grant of £1,000 / ha. (€1,506.70)[22] for short rotation coppice (SRC)
- a planting grant of £920 / ha. (€1,386.17) for miscanthus
- up to 50% of the cost of setting up an SRC producer group

The scheme's target is to plant 16,700 ha of SRC and 5,000 ha of miscanthus, producing 215,000 and 64,000 oven dried tonnes (odt) per year respectively. These targets have been missed by a large margin. Total area planted by the end of July 2006 was 1,160 ha for SRC and 3,370 ha for miscanthus. In total the area planted under the scheme amounted to 20% of the targeted level. A further 15,000 ha are due to be planted under the scheme in 2007 and 2008. Interest in the payments has increased over time. At the scheme's midway evaluation in 2003, less than 3% of the targeted land area was planted for each crop. Interestingly, proportion of SRC and miscanthus finally planted is likely to be the reverse of that initially predicted – i.e. miscanthus will take up approximately ¾ of the planted area[23].

A major reason identified for the low uptake of the grants is the risks borne by farmers and/or power stations in deciding whether to establish a bioenergy system (ADAS, 2003). Two of the grant criteria are particularly relevant to farmers:

[21] Fuel Source (e.g. wood) + Conversion Technology (e.g. combustion) + application (e.g. CHP plant) + delivered service (e.g. heat) = one chain
[22] The exchange rate used in these calculations is £1 = €0.6637 unless stated otherwise. This is the rate used in the EC monthly oil bulletin for 06/2004 http://ec.europa.eu/energy/oil/bulletin/2004_en.htm . A 2004 rate is chosen because this is the base year for Task 40 country reports.
[23] Personal communication with DEFRA, 2006

- *Crops must be for an energy end-use* - This means the farmer must either have a contract with an energy-producing customer or a letter of intent from the end user.
- *Crops must be located within a reasonable distance of the end-use* – 10 miles (16 km) for small installations, 25 miles (40 km) for larger installations. However, end users can make a case for an extension of the catchments area if there are no significant environmental impacts ensuring. In fact some end users have already done so.

(Source: DEFRA, 2006b)

The requirement for crops to be located near to the end-use obviously restricts the number of sites that could potentially grow energy crops. Also, as the scheme's mid-term evaluation (ADAS, 2003) points out, energy crops have a 2-4 year 'lead-in period' before any yield is produced. Therefore a proposed biomass power station will require planting to begin years before the station is constructed in order to ensure adequate fuel supply when the station is commissioned. The current situation is a 'chicken and egg' scenario where few power stations are being built due to the inadequate biomass supply infrastructure. This becomes a greater problem for larger power stations that must source their fuels from a wider area and require a greater diversity of potential suppliers. This risk in turn makes it harder for power stations to raise finance. The risk to farmers of not having an eventual market for their crop is not addressed by the Energy Crop Scheme, though the establishment grants do lessen the absolute financial commitment. Furthermore, the local end-user requirement means that farmers must have a particular local market for their produce and are discouraged from growing energy crops speculatively. The major market for local energy crops is for co-firing with coal (see co-firing section below). This is perhaps a more realistic option than stand-alone biomass plants since a number of coal-fired power stations are currently operating in the UK. However, the need for planting to occur close to the plant still restricts the potential supply of energy crops.

5. Biomass for Heat

The production of heat accounts for approximately 30% of total energy consumed in the UK, excluding transport (FES, 2005). One percent of this is generated from renewable sources. In 2005, renewable sources produced 485 ktoe of heat, of which 94% of the source energy came from biomass (DTI, 2006). In 2004, this figure stood at 599 ktoe[24]. The 04/05 decline was due entirely to a reduction in industrial wood consumption, which fell by 59%. The 2005 level is little over half the amount of biomass energy used for heat in 1996. The decline is mainly due to tighter emissions controls that discourage the burning of wood waste. Table 5 summarises the current UK biomass heat market. In theory, there is scope for this market to increase substantially were existing premises that are not supplied by the main gas grid to convert to renewable heat systems.

[24] NB these figures refer to the renewable energy input in heat generation

Table 5: Contribution of biomass to the UK heat market

Source	Contribution (TWh/y)
Wood combustion – residential	2.38
Wood combustion – industrial	3.09
Straw	0.84
Total	6.31

(Source: FES, 2005)

In FES 2005, information on the size of the off-gas-grid heat market is used to predict the technical potential, market potential and projected actual future demand for biomass heating. There are currently 4.42 million premises not connected to the main gas grid, with a further 160,000 predicted to be built by 2020. Converting all these premises to biomass heating would give a *technical* potential heat demand of 78.5 TWh/year. The off-gas-grid commercial and industrial heat markets could increase demand for biomass heat by a further 24.9 TWh / year and 75.5 TWh / year respectively.

To estimate the *market* potential, the study assumes that 25% of the off-gas-grid residential market would switch to biomass heat if conditions were favourable. It is also assumed that in the non-residential off-gas-grid market, space constraints will limit the installation of larger biomass boilers to 10% of the intermittent-use commercial sector, 15% of the continuous-use commercial sector and 15% of the industrial sector.
The actual market projections are based on assumed rates of market penetration: 5,000 – 20,000 boilers installed per year in the residential sector and 5% market penetration in the commercial and industrial sectors. The predicted market size by 2020 is shown in Table 6.

Table 6 Estimated biomass heat market in 2020

	Residential TWh/year	Commercial TWh/year	Industrial TWh/year
Technical Potential	78.5	24.9	75.5
Market Potential	19.6	3.0	11.3
Contribution Projection	2.4	2.2	8.5

(Source: FES, 2005)

Community heating also forms a potential source of demand for biomass heat. By 2020, the technical potential demand from this market could be 5.6 TWh/year, consisting of existing schemes and assuming community heating is installed in 10% of projected new developments. However, given space constraints and other difficulties in converting existing (natural gas) systems to biomass, FES (2005) assumes that only 5% of existing schemes will be suitable for biomass conversion, reducing the 2020 market potential to 0.36 TWh/year.

In terms of fuel costs per kWh of heat, biomass is already competitive with natural gas. FES, 2005 gives the gas price as 2.34 pence/kWh in the residential sector, compared to 1.5 pence/kWh in for wood pellet. The price competitiveness of biomass is likely to increase over time provided current upward trends in the price of domestic heating oil and natural gas in UK domestic and industrial markets continue. For domestic consumers, the real price of gas increased by 12.5% and the real price of heating oil rose by 25.8% from 2004-05 (DTI, 2006). The savings from the fuel are partially offset by the capital cost of installing a biomass boiler.

Assuming there is no economic incentive from government policy, FES (2005 calculates the internal rate of return on investment in a 10MW heat-generating system to be 21%. However, under the current Renewables Obligation scheme, renewable electricity commands a ROC[25] value in addition to the sales price of the electricity. This distorts the market by making it relatively more attractive for energy suppliers to find ways of using renewable sources (including biomass) in the generation of electricity rather than heat supply (Renewable Energy Association, 2006).

Some Government funds have been made available in recent years to provide demand-side support for renewable heat. This support comes in the form of grants for community organisations and households wishing to install renewable heat facilities. At present, the Low Carbon Buildings Programme[26] allows households to apply for a grant of up to 30% (50% for community organisations) of the cost of a biomass boiler, stove or heating system. The total funding available for the scheme from 2006-2009 is £78.5 million (DTI, 2006c). This is the equivalent of 15,700 domestic boilers (assuming a unit cost of £5,000). However, biomass is not the only form of renewable energy eligible for the scheme[27].

5.1 The UK wood pellet market

As a means of providing heat to domestic, small commercial and rural customers, wood pellet has several advantages over other forms of biomass. These include low moisture content, high energy density (and hence ease of transport and storage), the standardised nature of the product and its liquid-like properties (pellets can flow easily from a feeding mechanism into a boiler). However, wood pellet technology, and hence the wood pellet market, is a relatively new, emerging sector of the UK energy industry.

Traditionally, there has not been a wood pellet market in the UK. Initial research, development and demonstration began in 1999 under the EU-funded project *Introducing wood pellet fuel to the UK*. (DTI, 2001[28]). The project identified the 'Cluster Model' as the way in which the pellet market had successfully developed in other European countries. A cluster consists of a local network of supply, demand, distribution and maintenance – an integrated local system in which market infrastructure can develop.

Clusters in the UK are usually centred around a pellet production facility. For example Welsh Biofuels[29] and Balcas[30] in Northern Ireland both produce 50,000 tonnes of pellet

---

[25] ROC = Renewables Obligation Certificate. See UK Policies to Encourage Renewable Energy section
[26] http://www.lowcarbonbuildings.org
[27] Grants are available for low-carbon technologies including solar PV, solar thermal, microhydro, micro-wind, biomass, microCHP (including fuel cell powered microCHP) and heat pumps.
[28] Also see http://www.nef.org.uk/logpile/pellets/introduction.htm
[29] http://www.welsh-biofuels.co.uk
[30] http://www.balcas.com/site

per year. The Balcas facility is part of a wood products group. Some of the pellet is also used to fuel a biomass CHP plant operated by the firm. Production of pellet in the UK is small-scale, but they may increase in the future with the production of more wood from woodland management and the pelletisation of SRC and miscanthus in some areas, despite competition from the furniture board manufacturing industry which has a dominant position.[31]. A number of wood pellet producers have established a presence in the UK market[32]. The major market for imported wood pellet has been for co-firing with biomass in power stations. However, use of pellet in the institutional market (e.g. in schools) has increased in recent years.

5.2 Biomass CHP

In 2004, total inputs of renewable fuels into CHP were 2,744 GWh, representing 2.2% of total energy inputs into CHP (DTI, 2005). Most of the renewable fuels in question are waste products such as landfill gas, sewage gas and municipal waste. Current policies do not provide any specific support for biomass CHP, though biomass CHP plants do qualify for other support measures such as capital grants. ROCs can be claimed for the electricity produced from a biomass CHP plant. However, some support also exists for CHP schemes powered by natural gas, reducing the relative competitiveness of biomass schemes. Capital grants are available for good quality natural gas schemes and these are also exempt from the Climate Change Levy and European Emissions Trading Scheme.

FES, 2005 found that biomass CHP schemes are relatively unattractive compared to biomass heat-only facilities because of additional cost of capital. The rate of return on investment for operating a heat-led CHP scheme was estimated to be 5.4% compared with over 21% for a heat-only plant. However, the competitiveness of CHP improves when the ROC-value of the electricity is taken into account. At a ROC price of £45/MWh (€67.8) the return on investment from CHP and heat-only plant are equal. The average ROC price at the latest auction (April 2006) was £40.65 (€61.25)[33].

At present, there are a number of biomass CHP plants operating in the UK, though their aggregate contribution to the energy sector is small. Slough Heat and Power[34] operates a converted coal-fired facility that can be fed by wood chip and Short Rotation Coppice (SRC). A 30 MWe CHP plant fuelled by SRC and other woody materials is currently under construction[35].

6. Co-firing[36]

Co-firing of biomass with fossil fuels is the largest single energy market for biomass in the UK. As Figure 5 shows, there was no co-firing in the UK prior to 2002, yet in 2004 co-firing was the 3rd largest source of bioenergy behind combustion of MSW and

---

[31] Personal communication with Renewable Fuels Ltd
[32] For example, Renewable Fuels Ltd. http://www.renewablefuels.co.uk and TallOil, http://www.talloil.se
[33] http://www.nfpa.co.uk/nfpas/trackrecord.htm
[34] http://www.sloughheatandpower.co.uk
[35] http://www.sembutilities.co.uk/wilton10/
[36] Further details will be provided in a separate report

landfill gas. In 2005 2.5 TWh of electricity were generated from co-firing, an increase of 148% from the 2004 level (DTI 2006). From an operator's point of view, co-firing of biomass has the following major attractions:

- **Low capital investment costs –** existing coal or oil-fired power stations can be adapted to co-fire biomass at relatively low cost compared to the investment and commitment required to build dedicated biomass facilities.
- **Co-firing is a marginal activity –** this means that operators do not need to be totally committed to co-firing and always have the option to fire 100% coal or oil if suitable biomass feedstocks are not available.
- **Co-firing has short lead times** - operators do not have to invest in long-term supply networks and can purchase feedstocks as and when they become available.
- **Co-firing offers greater flexibility of fuel choice** - Operators can choose between a variety of feedstocks provided they meet the facility's technical specifications.

Despite these advantages, biomass is not price-competitive with coal on a cost-per-GJ basis and creates some difficulties with storage (biomass is bulkier), corrosion (biomass is wetter) and health and safety (biomass is more reactive).

From a GHG-abatement point of view, the benefit of co-firing is questionable. On the one hand it offers the easiest, largest source of carbon abatement, but at the same time co-firing can be criticised on the grounds that it allows suppliers to generate 'renewable' electricity using current-generation coal technology as opposed to investing in clean coal technologies or moving away from coal generation entirely.

Co-firing was included as a ROC-eligible source of electricity when the RO was introduced. It was intended as a "transitional technology" (DTI, 2006d) to encourage the development of biomass supply chains and energy crop production. The inclusion of co-firing made the combustion of biomass economically attractive in the short term. However, it was intended that co-firing would cease to be ROC-eligible from 2016 and that from 2009 an increasing proportion of the feedstocks should come from energy crops[37]. Initially, suppliers were permitted to claim a maximum of 25% of their ROCs from co-firing. From April 2006, this limit fell to 10%, effectively halving the number of co-fired ROCs that could be claimed. This cut has reportedly had a significant effect on the economics of co-firing. With the ROC limit set at 25%, independent generators were able to co-fire biomass and sell the ROCs to electricity suppliers. At 10%, it is only viable for vertically integrated companies (those that are both generators and suppliers) to continue with co-firing as their own operations are sufficient to satisfy meet the 10% limit[38].

Following the 2006 Energy Review (DTI, 2006d), it appears that co-firing "should be encouraged to play a long-term role in reducing carbon emissions" (p. 103). This means that since co-firing is not viable on a purely commercial basis, it will continue to receive some support under the RO. One proposal from the Review is that the existing cap on the co-fired ROCs be replaced with a banded system. Under this system, there would no

---

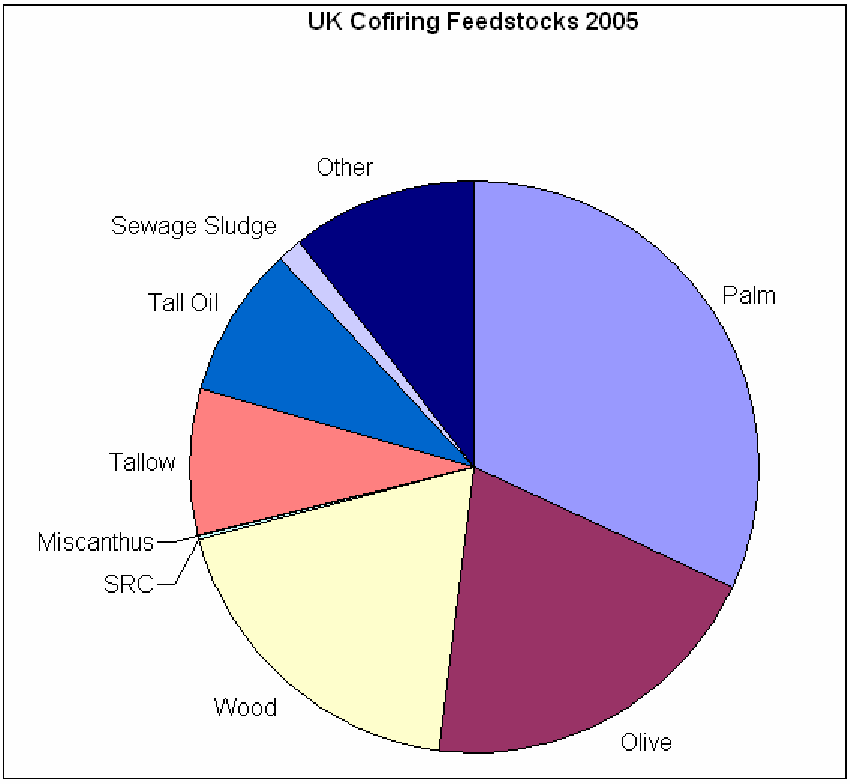
[37] The Renewables Obligation defines Energy Crops as "a plant crop planted after 31st December 1989 and grown primarily for the purpose of being used as a fuel". (See DTI, 2006f)

[38] Personal communication with Drax Power Ltd, 2006

longer be a limit on the amount of co-firing that would be ROC-eligible. However, co-firing would be allocated a lower band than other renewables (less than one ROC per MWh). In order to continue to support energy crop production, co-firing from energy crops would be allocated a higher band than co-firing of other biomass.

At present, the majority of co-firing feedstock in the UK is imported. Figure 6 shows the feedstocks used in co-firing in 2005. It shows that olive and palm products, crops that are not commercially cultivated in the UK, formed over half the co-firing feedstock in 2005. It is likely that substantial quantities of the other feedstocks, such as wood pellet, are also imported. However, detailed data on the origin of the feedstocks is not available. The most popular co-firing feedstocks were palm kernel expeller, palm kernels, wood pellet and olive cake. Ceteris paribus, processed feedstocks such as olive cake or wood pellet are preferred by operators since they require little modification to the coal-fired facilities or on-site processing of the feedstocks[39].

Figure 6



(Source: DTI, personal communication)

The combined share of SRC, granulated willow and miscanthus is small. These are the feedstocks that could be considered energy crops. From 2009, these crops will have to form an increasing proportion of the feedstock if co-firing is to continue. A typical coal plant in the UK is able to co-fire 5% by weight of its feedstock. Taking the 2004 level of coal consumed in electricity generation (50.51 Mt) as a benchmark, UK coal plants

[39] Ibid.

would be able to co-fire 2.53 Mt of biomass (DTI, 2005). Assuming that energy crops are planted with an annual yield of 10 oven dry tonnes per hectare per year[40], this would mean 250,000 ha of energy crops would be required to meet potential demand. This is almost ten times the target amount of land targeted under the Energy Crop Scheme discussed in the previous section. However, the fact that SRC and miscanthus are the only crops available for planting grants as energy crops does not exclude other crops from being eligible. Annual crops such as wheat and rapeseed can also be co-fired as energy crops, provided the crop concerned is grown specifically for this purpose[41].

Table 7 shows the potential electricity production from co-fired energy crops and imported biomass under current regulations. It assumes that total electricity supplied to customers remains at the 2004 level and that operators will use imported feedstocks in preference to domestic energy crops when not constrained by regulations. Reductions in the ROC limit for co-firing combined with an increase in the energy Crop requirement will cause the market for imported co-firing feedstock to fall sharply in 2011. This fall is partly offset by continued increases in the level of the Renewables Obligation overall.

Table 7: Potential effect of existing regulations on future electricity generation from co-fired energy crops and imported feedstocks

Total electricity supplied (2004) 344.23 TWh

Year	Renewables Obligation (% of electricity supplied)	Co-firing limit (% of ROC claim)	Minimum energy crop mix (% energy content)	Electricity from energy crops (GWh)	Electricity from imported biomass (GWh)
April 2009 – March 2010	9.7%	10.0%	25.0%	834.76	2504.27
April 2010 – March 2011	10.4%	10.0%	50.0%	1790.00	1790.00
April 2011 – March 2012	11.4%	5.0%	75.0%	1471.58	490.53
April 2012 – March 2013	12.4%	5.0%	75.0%	1600.67	533.56
April 2013 – March 2014	13.4%	5.0%	75.0%	1729.76	576.59
April 2014 – March 2015	14.4%	5.0%	75.0%	1858.84	619.61
April 2015 – March 2016	15.4%	5.0%	75.0%	1987.93	662.64

(Source: DTI, 2005)

[40] Annual yield for short rotation coppice ranges from 7 – 12 odt / ha. http://www.defra.gov.uk/erdp/schemes/energy/crops.htm

[41] There is still uncertainty, however, regarding the precise conditions needed for a crop to count as an energy crop under OFGEM definition

Until the changes to the co-firing regulations that were proposed in the Energy Review are clarified, it is unclear how the market for imported feedstocks will develop. Table 7 represents the future scenario stemming from the quantitative restrictions set out in the present RO framework. At present, the majority of co-firing feedstock is imported and purchased on spot markets. As long as there is demand for ROCs, operators can make a short-term decision whether to fire less than 100% coal, generating both electricity and ROCs. When a sufficient quantitative restriction is placed on the number of ROCs that can be co-fired, this opportunity is severely diminished as co-firing still requires ROCs to be economically viable.

Replacing the current quantitative restrictions with a system of banded ROCs could potentially restore the opportunity for operators to import favourably-priced biomass feedstocks as a marginal, ROC-creating activity. Even, if a new policy regime were to give preference to local energy crops, this would affect the price competitiveness of the imported feedstocks rather than restricting their absolute quantity. The level of co-fired imports would depend on their own market price, the price and availability of energy crops and the market price for ROCs rather than a system of restrictions as in Table 7.

7. Dedicated Biomass Power Plant

There are currently 14 dedicated biomass plants in the UK with an installed generating capacity of 50 kW or more. The combined generating capacity of these plants is 150,772 kW (OFGEM, 2006). The major bioenergy plants in the UK were designed to burn specific animal or plant by-products and many generate income from the production of by-products such as fertiliser or from the disposal of agricultural waste. Details of the largest plants (those with a capacity over 5,000kW) are given in Table 8 below:

Table 8: Dedicated biomass power plants in the UK, capacity >5,000 kW

Name of Plant	Generating Capacity	Details of Fuel Source	Operating Company
Ely Power Station	38 MW	Requires 200 kt of fuel per year Intended to burn straw. Also burns miscanthus and oil seed rape Consumes 160 kt of chicken litter per year.	EPR Ltd. http://www.eprl.co.uk
Eye Power Station	12.7 MW	Charges a fee to burn feathers and other agricultural waste. Plant also produces fertiliser	EPR Ltd. http://www.eprl.co.uk
Glanford Power Station	13.5 MW	Originally designed to burn poultry. Re-commissioned in 2000.	EPR Ltd. http://www.eprl.co.uk

PDM Widnes	9.5 MW	Now burns meat and bone marrow, for which a gate fee is charged. Burns animal by-products under a government contract	PDM Group http://www.pdm-group.co.uk
Thetford Power Station	38.5 MW	Burns poultry litter. Fertiliser produced as a by-product	EPR Ltd. http://www.eprl.co.uk
Westfield Biomass Plant	9.8 MW	Burns poultry litter. Fertiliser produced as a by-product	EPR Ltd. http://www.eprl.co.uk

(Source: OFGEM, 2006 and company websites listed above)

Other dedicated biomass plants are at the planning or construction stage. For example, a 30 MW plant designed for combustion of SRC, small roundwood, recycled wood and sawmill co-product is due to open in 2007[42]. The operator intends to source all fuel for the plant from the UK. Since the location is on the North-East coast of England (Teesside) close to a major port, the potential also exists for this plant to import biomass fuel.

Overall, the contribution of dedicated biomass plant to the UK energy sector has not developed as quickly as was hoped when the RO was introduced. This can partly be attributed to a low supply of domestic biomass on a significant scale. This in turn is partly due to the high levels of imported biomass in the co-firing sector and the consequent failure of the sector to stimulate energy crop cultivation. In terms of bioenergy trade, though it is possible that dedicated biomass plants be designed with the capability of accepting a variety of domestic and imported fuels, operators are unlikely to build plants to run specifically on imported fuels such as palm oil or wood pellet. This is because the prices of these feedstocks are relatively volatile, partly due to their suitability for several competing uses outside power generation. Buyers of wood pellet face competition from domestic and industrial users wishing to use it as a heat source while, palm products and, to a lesser extent, olive cake have a variety of uses in particular as animal fodder. Thus the creation of significant dedicated biomass plants not linked to a domestic fuel source is unlikely due concerns over the supply of competitively-priced feedstocks.[43]

8. Biofuels for Transport

Like all Member States of the European Union, the UK is subject to the Biofuels Directive (European Parliament and Council of the European Union, 2003). This requires the UK to set a minimum target for the penetration of biofuels into the transport fuel market. The Directive sets an indicative reference value of 2% by energy content of

[42] see http://www.sembutilities.co.uk/wilton10/index.html

[43] Personal communication with Renewable Fuel Supply Ltd.

all petrol and diesel placed on the market by the end of 2005, rising to 5.75% by the end of 2010.

At this time, the main policy for encouraging biofuels in the UK is a fuel duty incentive. This was introduced for biodiesel in 2002 and bioethanol in 2005. It guarantees that until 2008-09 duty charged on biofuels will be 20 pence / litre lower than for ultra-low sulphur petrol or diesel. In addition to this, grant support is available to aid the development of refining and processing facilities for biofuels (DfT, 2006). The Refuelling Infrastructure Grant programme provides grants towards the cost of installing refuelling points for alternative fuels, such as biofuels. In addition, subject to State Aid approval, cleanest biofuel processing plants may be able to write off the capital cost of biofuel processing equipment against taxable profits in the first year.

At present, the penetration of biofuels in the UK market is limited but growing. Biodiesel is available at over 138 filling stations, mostly as a 5% blend, petrol containing 5% bioethanol is available at 185 stations and E85 bioethanol is available at 11 stations. In 2005, total biofuel sales accounted for 0.18% of total fuel sales by energy content (DfT, 2006).

The UK has set a target that biofuels should reach 5% of fuel sales *by volume* in 2010/11, and 10% by 2015. Total fuel sales for 2010 are projected to be 47 billion litres (DfT, 2006b). A 5% volume target would therefore lead to UK biofuel demand of at least 2.3 billion litres. 5% is the maximum biofuel component that a blended fuel is permitted to have in order to comply with fuel standards EN 590 for diesel and EN 228 for petrol. It is therefore the maximum market penetration that can be achieved by blending biofuels with petrol and diesel and selling the mixture as a standard fuel for unmodified vehicles. The target level is considerably below the Biofuels Directive reference value of 5.75% by energy content. In order to exceed the 5% volume target and achieve the Directive's reference value, the market for higher blend biofuels such as E85 would have to grow considerably or the EN standards would have to be modified to allow higher blends of biofuel.

The 5% volume target will be supported by a Renewable Transport Fuel Obligation (RTFO). This will require 5% of fuel sales to come from renewable sources by 2010/11. The target will apply to fuel suppliers at the aggregate level, and will not include separate targets for biodiesel and bioethanol. Though the details of the policy have yet to be confirmed, it is expected that RTFO will operate in a similar form to the Renewables Obligation that exists in the electricity supply market. Under such a system, fuel suppliers would meet their obligation by supplying renewable fuels, buying Renewable Transport Obligation Certificates from other suppliers or paying a pre-determined buy-out price.

It is intended that the RTFO include a requirement to report on carbon savings and against sustainability indicators. This would be a system where Renewable Transport Certificates (RTC) are only issued for biofuels that can demonstrate, for example, a given level of greenhouse gas savings and avoided deforestation (E4Tech et al., 2005).

A number of biofuel production facilities are under construction in the UK to supply the anticipated increase in demand for 5% blended biofuels which is expected to increase further to meet the expected additional demand. There are two main biodiesel plants in the UK. One, operated by the Biofuels Corporation[44], has a capacity to produce 250,000 tonnes of diesel from vegetable oil crops such as rapeseed, palm and soybean[45]. The other, operated by Argent Energy[46], produces biodiesel from tallow and used vegetable oil. There is currently no production of bioethanol in the UK, though a number of plants are under construction or development.

In the current RTFO legislation, bioethanol and biodiesel are specified as the only two fuels that qualify towards suppliers' renewable fuels obligation. However, several other forms of biofuel are also being explored.

The first bioethanol production plant in the UK was to be a joint venture between British Sugar, BP and Dupont. However, it has recently been announced that the plant will instead be converted into the UK's first plant for the production of bio-butanol. Butanol, like ethanol, can be used as a biofuel and blended with petrol. Advantages of butanol include its higher energy content and the ability to blend higher concentrations of butanol with gasoline in unmodified vehicles. The disadvantage is that production techniques for bio-butanol are not yet as advanced as those for ethanol. The implications of the decision to convert the plant for the UK biofuel market remain to be seen.

It is possible to produce a transport fuel known as bio-oil through the pyrolysis of various biomass materials such as forestry, agricultural or municipal waste. This has yet to succeed on a commercial basis in the UK. Pyrolysis and gasification are advanced technologies capable of producing fuels in the form of gas, oil and char from biomass that is heated in the absence of oxygen. Though there is substantial research into these technologies in the UK[47], the UK's only planned facility for production of bio-oil went into liquidation in 2003 (Guardian, 2003; van der Horst, 2005).

9. International biotrade

It is difficult to obtain detailed information concerning the level of bioenergy imports into the UK since information at a company or sectoral level is commercially sensitive in nature. At the same time, international trade statistics often do not classify products (such as wood pellet) in sufficient detail. Much of the material imported is for co-firing or use in pelletised form. It is difficult to determine trade patterns for co-firing since imported feedstocks are typically purchased on spot markets and operators have the ability to switch between different suppliers and different feedstocks to pursue best value for money. A variety of feedstocks can also be used for the manufacture of pellets, provided the pellets meet stated specifications in terms of size, heat and moisture content.

The UK is nascent producer and consumer of many forms of bioenergy. This means that trade in bioenergy exists for products consumed for energy in the UK that are not yet produced domestically. For example, 85 million litres of bioethanol were imported into

---

[44] http://www.biofuelscorp.com
[45] Personal communication with the Chief Executive of Biofuels Corporation, (05/07/06)
[46] http://www.argentenergy.com
[47] See http://www.thermalnet.co.uk a consortium of research activity into biomass combustion, pyrolysis and gasification

the UK for use in road transport in 2005. This represented 0.17% of total fuel sales by volume (DfT, 2006).

9.1 The potential role of certification[48]

Certification is unlikely to solve social, economic, environmental, and sustainability problems posed by land use, resources, etc as currently most of the schemes are not an effective substitute for positive governmental legislation. In addition, if certification schemes are not easily and effectively implemented they can hinder rather than enhance international biotrade. However, in the longer term if some kind of rules capable of satisfying the wider international audience can be agreed, certification can play an important role in promoting sustainable international biotrade.

Dealing with biofuels trade is not easy given their many wider implications. Currently none of the operational standards or certification systems is effectively carried out and considerably more work need to be done at local level in the process of certification definition of standards, verification, biodiversity, use of natural resources, agricultural and management practices, social benefits, etc. An additional area where much needs to be done is the training of personnel on certification issues.

10. Conclusions and recommendations

International biotrade in gaining in strength as the number of countries trading in biomass for energy is increasing. Rapidly increasing demand is furthermore causing problems in the supply chain, largely due to unforeseen demand and immaturity of this market. UK is playing an increasing role in biotrade as discussed in this report; this trend is likely to continue given the size of the UK market and policies that favour RE, and in particular biofuels.

However, the rules that govern biotrade are unclear and often confusing and unnecessarily complex. Problems with statistical classification, quality standards, certification, sustainability issues, are good examples. A further issue relates to the unwillingness of those involved in biotrade to provide information as this is still regarded by many traders as “commercially sensitive”.

The UK has considerable potential for expansion of biotrade as favourable policies are being put in place that will further strengthen the biofuels market, particularly co-firing and CHP. Although UK has considerable capacity to supply this market from domestic sources, there are various reasons why international biotrade is expected to play much greater role in the future: i) as indicated in this report, the UK market is potentially quite large; ii) the cost of feedstocks are high in comparison to many other countries; iii) the need to allow market forces to have a much greater role, which is highly likely to result in large-scale imports. An element of competition will be very healthy for the industry.

[48] As Task 40 is also preparing a study on certification, this section will be very brief.

Perhaps one of the greatest doubts hangs over the co-firing market which, despite the Energy Review, remains unclear for two main reasons: i) the amount of benefits that co-firing may ultimately receive, and ii) the potential role of clean coal technology and the possible impacts on co-firing also remains unclear. The long-term future of this industry requires that these uncertainties be removed.

Recommendations

- There is a strong need to improve the statistical base of biotrade. Clear statistical classification will help considerably in assessing this market
- Market forces should be allowed to play a key role in the development of biotrade to ensure healthy competition
- Help is needed to create a solid infrastructure (e.g. volume, logistics, etc)
- Studies to determine the socio-economic and sustainability issues in greater detail
- Further research into certification and standardisation issues

11. References

ADAS, 2003. The Mid-term Evaluation of the England Rural Development Programme, Energy crops Scheme http://www.defra.gov.uk/erdp/reviews/midterm/final_report/default.htm

BBC, 2006. UK Population breaks through 60m. BBC News online story, 24/08/06 http://news.bbc.co.uk/2/hi/uk_news/5281360.stm

Biofuels Corporation, 2006. Personal communication wit the Chief Executive Officer, (05/07)

Biomass Task Force, 2005. Biomass Task Force, Report to Government. http://www.defra.gov.uk/farm/crops/industrial/energy/biomass-taskforce/pdf/btf-finalreport.pdf

Carbon Trust, 2005. Biomass Sector Review for the Carbon Trust. http://www.carbontrust.co.uk/Publications/CTC512.pdf

DEFRA, 2001. Umbrella climate change agreement for the paper sector. http://www.defra.gov.uk/environment/ccl/pdf/203tpf.pdf

DEFRA, 2005. EU Emissions Trading Scheme. Approved National Allocation Plan (Phase 1). http://www.defra.gov.uk/environment/climatechange/trading/eu/index.htm

DEFRA, 2006. Personal communication with Industrial Crops Division (07/07)

DEFRA, 2006b. Web page detailing establishment grants for Energy Crops Scheme http://www.defra.gov.uk/erdp/schemes/energy/establishment.htm (Accessed 03/09)

DETR, 1998. Nationwide Survey of Community Heating, (Final Report), BRECSU

DfT, 2006. Promotion and Use of Biofuels in the United Kingdom http://www.dft.gov.uk/stellent/groups/dft_roads/documents/pdf/dft_roads_pdf_611908.pdf

DfT, 2006b. Towards a UK Strategy for Biofuels – Public Consultation http://www.dft.gov.uk/stellent/groups/dft_roads/documents/pdf/dft_roads_pdf_028393.pdf

Drax Power Ltd., 2006 Personal communication with Alternative Fuels Project Manager, (04/07)

DTI, 2001. Introducing Wood Pellet Fuel to the UK http://test.netgates.co.uk/nre/pdf/BU100623.pdf

DTI, 2003. Energy White Paper. Our Energy Future, creating a low carbon economy. http://www.dti.gov.uk/energy/energy-policy/energy-white-paper/page21223.html

DTI, 2005. Digest of United Kingdom Energy Statistics (DUKES 2005) http://www.dti.gov.uk/energy/statistics/publications/index.html

DTI, 2006. Energy Trends, June 2006 http://www.dti.gov.uk/energy/statistics/publications/trends/index.html

DTI, 2006b. Quarterly Energy Prices, March 2006 http://www.dti.gov.uk/energy/statistics/publications/prices/index.html

DTI, 2006c. Our Energy Challenge: Power from the People: Microgeneration Strategy. Annex B, low carbon buildings programme.
http://www.dti.gov.uk/energy/sources/sustainable/microgeneration/strategy/page27594.html

DTI, 2006d. The Energy Challenge. Energy Review. A report
http://www.dti.gov.uk/energy/review/page31995.html

DTI, 2006e. Digest of United Kingdom Energy Statistics (DUKES 2006)
http://www.dti.gov.uk/energy/statistics/publications/index.html

DTI, 2006f, Best Practice Brochure: Biomass Co-firing Best Practice. URN 05/1160
http://www.dti.gov.uk/publications/index.html

Energy Business Review, 2006. Volatility the only certainty in the EU carbon market. *Energy Business Review*, 08/05/2006
http://www.energy-business-review.com Accessed 15/09/06

European Parliament and Council of the European Union, 2003. Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport. *Official Journal of the European Union*. 17/05/03, L 123/42

Eurostat, 2006. Lookup of Energy Intensity Statistics, http://ec.europa.eu/comm/eurostat/ . Accessed 25/06/06

Eurostat, 2005. GDP per capita in 2004. News Release 75/2005, 03/06/2005. Eurostat Press Office, Luxembourg.
http://europa.eu.int/comm/eurostat/

E4tech et al., 2005. Feasibility study on certification for a Renewable Transport Fuel Obligation
http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_610366.pdf

Forestry Commission, 2005. Global Forest Resources Assessment 2005. United Kingdom of Great Britain and Northern Ireland Country Report
http://www.forestry.gov.uk/statistics

Forestry Contracting Association, 2003. Woodfuel Resource in Britain: Main Report
http://www.dti.gov.uk/energy/page15009.html

Future Energy Solutions, 2005. Renewable Heat and Heat from Combined Heat and Power Plants – Study Analysis and Report
http://www.defra.gov.uk/farm/crops/industrial/energy/pdf/fes-renewable-chp.pdf

Future Energy Solutions, 2005b. Climate Change Agreements. Results of the 2nd Target Period Assessment http://www.defra.gov.uk/environment/ccl/pdf/cca_jul05.pdf

HMRC, 2006. Climate Change Levy in depth http://customs.hmrc.gov.uk . Accessed 23/06/2006

OFGEM, 2006. Summary of ROCs issued since April 2004 & Accreditation Statistics.
http://www.ofgem.gov.uk . Accessed 28/06/2006

ONS (Office for National Statistics), 2006. News Release: UK population grows to more than 60 million. 24/08/2006.
http://www.statistics.gov.uk/pdfdir/pope0806.pdf
Accessed 30/08/2006

Renewable Energy Association, 2006. The Government's Energy Review, submission by Renewable Energy Association
http://www.r-p-a.org.uk/content/images/articles/0603EnergyReviewFinal(1).pdf

Renewable Fuels Ltd., 2006. Personal Communication with Commercial Manager (09/08)

Renewable Fuel Supply Ltd., 2006 Personal Communication (02/08)

Guardian, 2003. Farmers burned as green energy plant faces export.
The Guardian Saturday, May 31
http://www.guardian.co.uk/guardianpolitics/story/0,,967565,00.html

Van der Horst, 2005. 'UK biomass energy since 1990: the mismatch between project types and policy objectives', *Energy Policy*, 33, 705-716

Appendix A:

Table A1: ROCs issued in calendar year 2004

Energy Source	Number of ROCs Issued (1 ROC = 1 MWh)
Biomass	831,823
Biomass and waste using advanced conversion technology	9,173
Co-firing biomass with fossil fuels	1,574,502
Hydro (only schemes under 20 MW are ROC-eligible)	1,876,327
Landfill gas	3,561,925
Micro-hydro (schemes with capacity of less than 1.25 MW)	47,176
Off-shore wind	200,341
On-shore wind	1,564,504
Photovoltaic	0
Sewage gas	223,586
Total	13,685,286

(Source: OFGEM, 2006)

Appendix B:

This section contains estimates of the geographical potential, technical potential and economic potential of biomass resources in the UK. The estimates are calculated using information from Table 3. This data is from Biomass Task Force, 2005 (BTF05). Adjustments have been made to make the data comparable with definitions of geographical, technical and economic potential given in the document *Format for Final Versions Task 40 country reports* on the Task 40 website[49].

No attempt is made here to estimate the implementation potential of biomass in the UK. Implementation potential is defined as "The maximum amount of the economic potential that can be implemented within a certain timeframe, taking (institutional) constraints and incentives into account". In the UK, incentives regarding the development of biomass are subject to change (especially co-firing). In addition, most schemes relevant to bioenergy do not cover supply and demand in an integrated manner i.e. they are not designed with an assumption that the bioenergy used will come from any specifically-chosen source. Hence it is difficult to predict, a priori, the effect of a given policy incentive that encourages the use of bioenergy on the UK's indigenous bioenergy resources (as opposed to the level of bioenergy imports).

Geographical Potential – "the theoretical potential at land area available for the production of biomass for energy, from both residues (e.g. forestry and agriculture) and from dedicated energy crop plantation"

This figure is derived from information in Table 3, adjusted as shown below. Mid-point values are used where a range of figures are given in BTF05.

[49] http://www.bioenergytrade.org. Access to the document *Format for Final Versions Task 40 country reports* is restricted

Table B1: Estimate of geographical potential of available biomass in the UK

Type of Biomass & Methodology	Calculations	Estimated Energy content (TJ)
Forestry waste and arboricultural arisings		
BTF05 figure is from Forestry Contracting Association, 2003 (FCA03). It assumes competing markets take a given proportion of the wood and has some element of future projection. Figure used here is FCA03 figure without competing markets.	3,312,000 odt	
Northern Ireland Adjustment:	1 + (83,000 * 2,665,000)	
FCA03 figures do not include forestry resources in Northern Ireland. Forestry Commission, 2005 gives total woodland area in Great Britain as 2,665,000 ha. and Northern Ireland as 83,000 ha.	= 1.0311	
Assuming the same use of land in GB and NI	3,312,000 * 1.0311 = 3,415,150.47 odt	
Energy content, using same conversion factor as BTF05. Figure is an adjustment of Table 3	(3,415,150.47/1,460,000) * 23,944 =	**56,008.47**
Waste Wood (industrial)		
From BTF05, 6Mt of wood waste produced annually, of which 3Mt is good quality wood suitable for recycling and 3Mt is poor quality wood only suitable for waste or energy use	6,000 odt of biomass therefore energy content assumed to be twice that given in table 3 2 * 35,700 =	**71,400**
Dedicated Energy Crops		
Carbon Trust, 2005 gives UK set-aside land as 680,000 ha. BTF05 assumes 25,000 ha. are planted, roughly the amount targeted under the Energy Crops Scheme. BTF05 results are scaled-up to assume that 680,000 ha. are planted.	(680,000 / 25,000) * 308,375 = 8,387,800 odt (8,387,800 / 308,375) * 5,305.5 =	**144,309.6**
Cereal Straw		
BTF05 gives annual straw production as 9.5 Mt/year, suggesting that 3Mt are available without using straw otherwise ploughed into the soil or used as animal feed. Assumed only excess straw is used, therefore results as per BTF05	3,000 odt =	**45,000**
Geographical Potential Biomass Energy		**316,718.07**

Technical Potential – “the geographical potential reduced by losses due to the process of converting primary biomass to secondary energy carriers”

Efficiency of conversion from primary to secondary energy is assumed to be as per BTF05. i.e. 30% for electricity, 85% for heat, 85% for heat and electricity. Technical potential is therefore estimated at:

Electricity	**-**	**95,015.42 TJ**
Heat	**-**	**2,692,210.36 TJ**
Electricity and Heat	**-**	**2,692,210.36 TJ**

Economic Potential – "The technical potential that can be realised at profitable levels. This can be depicted by a cost-supply curve of secondary biomass energy."

No attempt is made here to estimate the potential supply of bioenergy in the UK as a function of the cost of secondary energy from biomass. However, an estimate of the economic potential for biomass energy is made by adjusting the geographical potential for more restrictive assumptions concerning the availability of biomass.

Table B2: Estimate of economic potential of available biomass in the UK

Type of Biomass & Methodology	Calculations	Estimated Energy content (TJ)
Forestry Waste and Arboricultural Arisings		
Assume only the biomass not consumed by other industries is available for bioenergy. Figure is as per FCA03.	1,314,000 odt	
Northern Ireland Adjustment:	1 + (83,000 * 2,665,000)	
See Table B1	= 1.0311	
Assuming the same use of land in GB and NI	3,312,000 * 1.0311 = 3,415,150.47 odt	
Energy content, using same conversion factor as BTF05. Figure is an adjustment of Table 3	(1,314,000/1,460,000) * 23,944 =	**21,549.6**
Waste Wood (industrial)		
Assume only poor quality waste wood is available for bioenergy. Result is therefore as per BTF05	3,000,000 odt	**35,700**
Dedicated Energy Crops		
BTF05 assumed 25,000 ha. would be planted. Energy Crop Scheme target was 21,700, of which only 20% was planted. Assume 20% of 25,000 ha. planted (some crops may be planted outside the scheme, such as annual crops)	5,305.2 * 0.2 =	**1,061.1**
Cereal Straw		
Assume cereal straw not used for fodder or ploughed back onto land is available. Therefore as per table B1		**45,000**
Primary Economic Energy		**103,310.7**
Economic Potential		**30,993.21**
Electricity only		
Economic Potential		**87,814.1**
Heat only		
Economic Potential		**87,814.1**
Electricity & Heat		