Daniel Crowe 0208531 Energy Resources ENV 2E02- Individual Report
Adviser: Keith Briffa

Biomass Energy

In this report I shall be dealing with the potential energy yields from agricultural and forestry sources- biomass energy. This does not include municipal, agricultural or industrial wastes.

There is a good opportunity for biomass and biofuels to play a significant part in supplying the UK with energy. As biomass fuels are produced from plants, they are renewable. Of course, they are only truly renewable if their production is sustainable. In terms of the national energy demand of the UK, for electricity, heating and transport, the potential for home grown biomass fuels is relatively small. However, in terms of achieving the 10% Renewables Obligation, biomass fuels could make up a significant proportion.

Acquiring energy from agricultural sources can be a complex process, dependant on a variety of factors. The main limiting factor to biomass energy production is the small land area available in the UK, relative to energy demand. For example, as calculated in my own Final Project, it would take about 87% of all the agricultural land in the UK, to grow enough oilseed rape to produce enough biodiesel to run all the diesel vehicles in the UK for a year. Furthermore, this would be destructive to biodiversity, soil nutrients and water tables and would be completely unsustainable. This report will attempt to assess the amount of biomass energy that can be produced in the UK, balancing reasonable land use and a significant energy yield.

Land availability is limited further by competition from other industries and land uses. With the set aside land scheme in operation, mainly in England and Scotland, there is land available that should have less competition for its use. The extent of this, and the potential yields from this land will be examined later.

The performance of agricultural products is inherently dependant on weather conditions and soil quality, and yields vary from year to year. This may make it difficult to guarantee a steady supply of biomass energy, meaning that the national energy supply could not fully rely on biomass, aside from the other limitations.

Infrastructure, processing facilities and demand for biomass fuels is currently limited. With policies to encourage the production and use of biomass, it will probably still take 10-20 years for the required farm modifications, infrastructure improvements, construction of power plants and boilers, and conversion of vehicles to be completed. This time delay will be incorporated into the projections. I believe that government subsidies to help consumers switch from fossil fuels to biomass fuels will be essential, particularly in the promotion of transport biofuels, and community heating projects.

Persuading farmers to start producing energy crops should not be the greatest challenge. Reforms to the EU Common Agricultural Policy (CAP) are helping farmers to move away from intensive food production. The main impetus here is the change from subsidising food production by the yield obtained, to supplying a subsidy relating to farm size. If the demand for biomass is high enough, crops such as forestry for energy, oilseeds (for biodiesel), high carbohydrate crops (e.g. Sugar beet for bioethanol) and fast growing energy crops like Miscanthus grass could become very profitable.

Current use of biomass energy and biofuels in the UK

- **Electricity from Biomass**

This involves burning suitably processed plant matter in a furnace, creating steam and powering turbines to produce electricity.

Current Output: Negligible

- **Transport biofuels:**

Bioethanol- replacement for petrol: Negligible

Biodiesel: 20 Million Litres[1]

40.128 GJ/tonne [2]
0.840 KG/litre [3]

(1000 KG = 1 tonne)

Therefore: 20m litres= 16,800,000 KG

16,800 tonnes= 674,150.40 GJ

= 0.674 PJ

Heat Generation- biomass used for space and water heating:

- Domestic: 204,200 tonnes of oil equivalent
- Wood for Industrial: 265,600 tonnes of oil equivalent

(1 toe = 46GJ)

= 469,800 toe
= **21.6 PJ**

(Essentially wood energy)

Currently (2003-2004), around **22PJ** of energy is produced from biomass in the UK. Now I assess the potential amount of energy that could be gained from UK produced biomass crops.

[1] Customs and Excise, 2003
[2] (DFT), 2002.
[3] (DFT), 2002.

Potential Extra Biomass Availability

This section analyses the most suitable sources of biomass energy. The potential yield is calculated.

Forest By-products

Product	Scotland	England	Wales	Britain
Stemwood 7-14 cm diameter	606	298	128	1032
Poor quality stemwood	113	94	70	277
Stem tips	12	14	5	31
Branches	116	225	68	409
Sawmill product	404	290	166	860
Arboricultural arisings	22	456	14	492
Short rotation coppice	0.6	16	0.2	17
Total	**1,274**	**1,393**	**451**	**3,118**

Table 1. Current potential operationally available woodfuel resource in the absence of competing markets, by country (thousand odt y^{-1})

Source: DTI, 2004

=3.1 million dry tonnes/ year = 62,000,000 GJ/year (20GJ/dry tonne)

X 0.35 Efficiency= 21.7 PJ of ELECTRICITY

or

X 0.9 efficiency= 55,800,000 GJ

= 55.8 PetaJoules of HEAT

Potentials for Using Set-Aside for Biomass:

Available set aside: 681,145.3 /year (DEFRA)

Biofuels for transport

Crops should be grown in a rotation to ensure sustainable production, preventing build up of diseases and maximises soil fertility. A suitable rotation for a farm producing energy crops would be the following:

Year 1: Sugar beet

Year 2: Oilseed Rape

Year 3: Fallow or other crop

This means that the amount of set aside land available for each crop is a third of the total (227,048 ha)

Bioethanol:

Energy Content: 26.7 GJ/tonne of bioethanol

Density: 0.789 KG/ litre

1 Tonne Sugar Beet= 86.7 Litres of Bioethanol[4]

Tonnes sugar beet/ Hectare: 54.0

Sugar Beet Potential Yield on Set Aside: 54.0 X 227,048.4= 12,260,613.6 Tonnes

= 1,062,995,199.12 Litres of Biodiesel

= 838,703,212.11 KG

= 838,703.2 Tonnes Biodiesel

= 22,393,375.76 GJ

= **22.4 PJ from Bioethanol**

Biodiesel:

- Typical OSR Yield in Tonnes / Hectare[5]: **3.25**
- Oil content of harvested Oilseed Rape[6]: **40%**
- Rape Seed Oil to Biodiesel conversion rate[7]: **97%**

[4] House of Commons, 2003

[5] DEFRA, 2004, and House of Commons, 2003- a typical, although optimistic figure.

[6] Kimber and McGregor, 1995

[7] A highly efficient conversion. Kusdiana and Saka, 2000- Rates of 95%-98% may well be possible.

So, 227,048.4 ha of Set Aside= 286,326.4 Tonnes of Biodiesel

= 11,489,705.8 GJ/Year

= **11.5 PJ from Biodiesel**

Therefore, using set aside for biofuel production; a feasible total energy yield is 33.9 PJ

Here are two options for producing electricity and heat from biomass:

Forestry:
10 Dry Tonnes/hectare/year (after 30 years growth)
20GJ/ Dry tonne

681,145.3 Hectares X 10 tonnes/year = 6.811 million dry tonnes/year
=136,220,000 GJ/year
=122,598,000 GJ/year (at 90%)
=122.6 PetaJoules/year of HEAT

or = (35%) 47,677,000 GJ/year
= 47.7 PJ /year of ELECTRICITY

or Energy Grasses (Miscanthus)
15 GJ/Dry Tonne
15 Dry Tonnes/hectare/year

681,145.3 ha X 15t = 10.217 million tonnes/year
= 153,257,692.5 GJ/year
= 137,931,923.3 GJ/year (at 90% efficiency)
= 137.9 PetaJoules/ year of HEAT

or = 53,640,192 GJ/year (35%)

= 53.6 PJ/ year of ELECTRICITY

PROJECTIONS

Here I assess the potential energy that can be gained from biomass in the UK, and recommend the most suitable use of the energy.

- Projections for Heating, Electricity and Transport are mutually exclusive i.e. the figures are assuming dedication of set aside land to that sector. If a mix of uses is to be obtained, then potential energy yields from each sector will be reduced accordingly.
- Assumes no competition for land and resources from other industries.
- Levelling off points assume limits imposed by finite land area, and do not account for possible improvements in processing technology and agricultural techniques. (Both could increase energy yield from biomass)

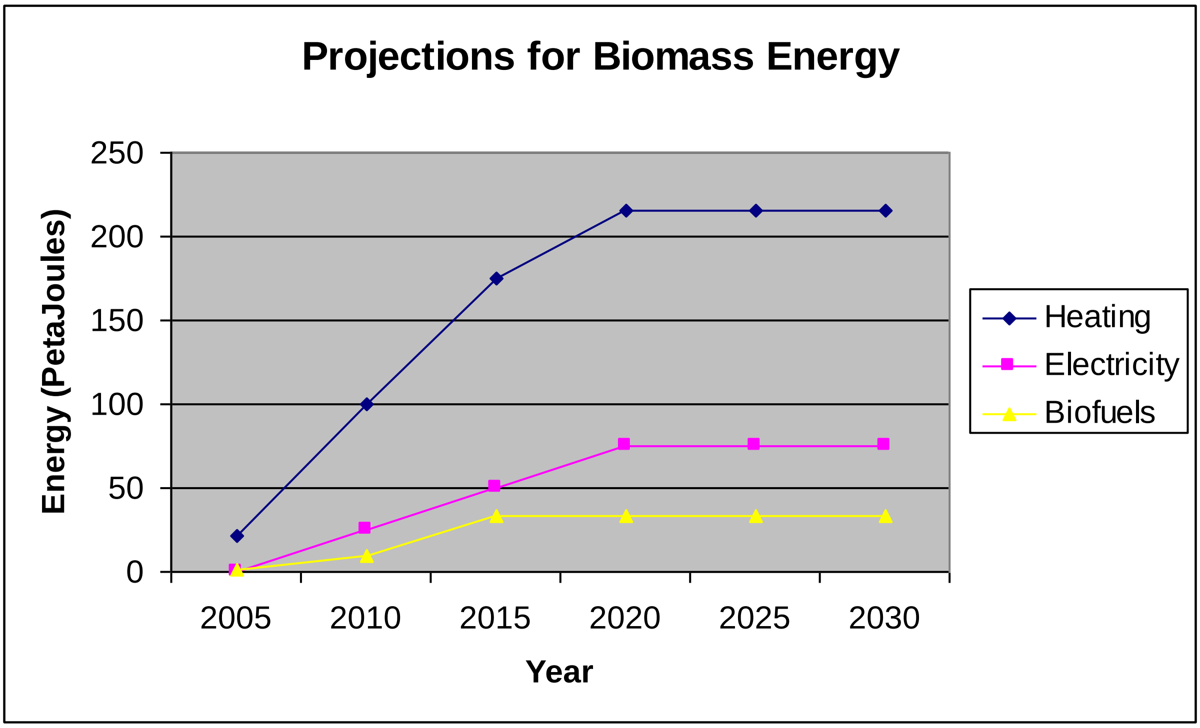
YEAR:	2005	2010	2015	2020	2025	2030
Heating	21.6	100	175	215.3	215.3	215.3
Electricity	0	25	50	75.3	75.3	75.3
Biofuels	0.674	10	33.9	33.9	33.9	33.9

Heating = Current (wood)+ Forest By-products+ Energy Crops on Set Aside

Electricity = Forest by-products+ Energy Crops on Set Aside Land

Transport = Biodiesel+ Bioethanol

(Figures in Peta Joules)



Recommendation

I recommend that the most efficient way of using the available land for biomass production is to use current forestry by-products in addition to set aside land growing an energy crop such as Miscanthus. Forestry may be favourable in that it is probably more reliable, as well as more attractive to the landscape, but it will take around 30 years to gain a stock of trees that can be sustainably harvested.

This resource should be used for heat generation, preferably in the local area of production. This will cut down on the financial and energy costs of transport of the energy vector. This **215.3 PJ** of Heat can either be considered as a replacement for natural gas, oil or coal, or as a reduction in electricity demand.

Using energy crops for transport biofuels does not have a large enough energy yield to compete with heating.

References

Department for Environment, Farming and Rural Affairs (DEFRA), 2004. *2004 Harvest: Provisional Estimates Of Oilseed Rape Production United Kingdom.* www.defra.gov.uk

Department of Trade and Industry, 2004. *Woodfuel Resource in Britain*. www.dti.gov.uk

Department for Transport (DFT), 2002. *International resource costs of biodiesel and bioethanol*. www.dft.gov.uk

House of Commons, 2003. *Memorandum submitted by the Agricultural Biotechnology Council*. The Minutes of Evidence of a report regarding the biofuels obligation.
http://www.publications.parliament.uk/pa/cm200203/cmselect/cmenvfru/929/3091012.htm

Kimber, D., and McGregor, D. I., 1995, *Brassica Oilseeds: Production and Utilization*, CAB International

Kusdiana, D., and Saka, S., 2000, *Kinetics of transesterification in rapeseed oil to biodiesel fuel as treated in supercritical methanol*. Fuel, **80** (2001) 693-698.