Annex A

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

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

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

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

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

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

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

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

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

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

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

Yield ranges used:

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

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

Calorific values used:

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

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

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

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

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

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