Programme Area: Bioenergy

Project: Energy From Waste

Title: Current Waste Data and Collection Plan Report

Abstract:

This deliverable is number 1 of 3 in Work Package 1 and forms the basis of the existing information on UK Waste data by means of identified data sources, detailed models of waste arising and forecasts of future waste arising.

This report highlights the arising, composition and energy potential of these wastes, which uses existing data to model this information. A sampling plan has been provided in this report which will enhance the existing data, providing current information on the composition in terms of physical content, elemental and calorific content.

Context:

The Energy from Waste project was instrumental in identifying the potential near-term value of demonstrating integrated advanced thermal (gasification) systems for energy from waste at the community scale. Coupled with our analysis of the wider energy system, which identified gasification of wastes and biomass as a scenario-resilient technology, the ETI decided to commission the Waste Gasification Demonstration project. Phase 1 of the Waste Gasification project commissioned three companies to produce FEED Studies and business plans for a waste gasification with gas clean up to power plant. The ETI is taking forward one of these designs to the demonstration stage - investing in a 1.5MWe plant near Wednesbury. More information on the project is available on the ETI website. The ETI is publishing the outputs from the Energy from Waste projects as background to the Waste Gasification project. However, these reports were written in 2011 and shouldn't be interpreted as the latest view of the energy from waste sector. Readers are encouraged to review the more recent insight papers published by the ETI, available here: http://www.eti.co.uk/insights

Executive Summary

This report is the first deliverable of work package 1 and aims to present the existing information on UK waste data by means of identified data sources, detailed models of waste arisings and forecasts of future waste arisings. Based on the data available in the public domain and, following a validation workshop with a number of leading experts in the field of waste management, the knowledge limitations have been identified.

The UK currently produces around 33 million tonnes of municipal solid waste [MSW], 72 million tonnes of commercial and industrial [C&I] wastes, 115 million tonnes of construction and demolition [C&D] wastes and 3 million tonnes of agricultural wastes. This is a total of over 220 million tonnes of waste. The MSW and C&I mixed waste streams consist of large amounts of different components which have the potential for energy recovery, such as paper, card, plastics, organics [food and green waste] and textiles.

Component	MSW [% Wt]	C&I [% Wt]
Paper and cardboard	17.6	32
Plastic film	6.3	7
Dense plastic	7.4	8
Textiles	3.8	2
Other combustibles	14.4	16
Glass	3.5	4
Other non-combustibles	4.4	6
Food/kitchen waste	26.7	13
Other organics	5.9	2
Metal	3.6	4
Household hazardous	0.6	1
WEEE	1.7	1
Fines	4.1	4

C&D waste consists largely of soils and aggregates, which are inert materials containing very little energy value. However this waste stream provides a valuable source of wood waste, which certainly has the potential for energy uses.

This report highlights the arisings, composition and energy potential of these wastes, which uses existing data to model this information. A sampling plan has been provided in this report which will enhance the existing data, providing current information on the composition in terms of physical content (i.e. paper content), elemental and calorific content. Additionally the samples collected will enable a comprehensive test program using thermochemical and biological energy recovery processes in work package 2.

The following table highlights the key benefits of the sampling regime:

	Current understanding			Post-sampling understanding		
Parameter	**MSW**	**C&I**	**C&D**	**MSW**	**C&I**	**C&D**
Composition	Yes	Yes	Yes	Yes	Yes	Yes
Calorific value	Yes	Single material values are known for specific materials, e.g. wood and plastic waste components; Missing data: there are no data for the calorific and elemental mix for complete waste streams [C&I and C&D].		Yes	Yes	Yes
Elemental content	Yes			Yes	Yes	Yes
Seasonal variation	Yes	No		Yes	Yes	Yes
COMBINED	No report provides a comprehensive summary of all the compositional information for individual waste streams, therefore with the current level of publicly available information it is unreliable and not validated to make reasonable comparisons across the UK			The sampling and analysis will combine all of the above compositional information, for individual waste components and for overall waste samples [i.e. mixed C&I]		
Regional and National context	Currently a number of recent reports enabling a good comparison of regional, national and seasonal variations	Some reports on regional and national levels, however there is no true basis for a comparison of recent data across these levels		Able to compare data obtained with existing information for reliability analysis, and for further understanding the regional, national and seasonal variations	Good basis for comparison with previously published data to gain a strong understanding of the regional and national differences, and to understand the changes in waste arisings over the past 5-10 years.	
OVERALL	Combined understanding of the compositional parameters does not allow a strong understanding of the overall energy recovery potential of these materials. A focused sampling regime would allow for a greater understanding of this in collaboration with the existing data			Overall an improved understanding of the compositional content of UK waste materials, along with an improved capability to compare collected data with existing data for a widespread, national and regional, view of energy recovery potential and the spatial and seasonal variation		

In terms of the current and post-sampling knowledge and understanding of waste materials in work package 1, the understanding of the composition of C&I and C&D waste arisings will be greatly improved. The compositional information for MSW will be validated by the sampling. The understanding of the detailed characteristics of individual components of waste [i.e. paper, wood, plastics etc] will be further understood, however importantly these will be understood in the context of arisings and physical composition of the waste sources from which they originate. The comprehensive analysis will also provide proximate and ultimate analysis alongside CV data for all components- data which is not readily available otherwise.

The sampling and detailed waste analysis will compliment and assist in the other work packages of the overall research programme, for example the technology modelling and the development of the energy from waste maps. Finally, the sampling regime will allow the reliability of validity of existing waste data as well as test current reports and inform seasonal variation.

Contents

Figures and Tables

Glossary

CA- Civic amenity site [a site which contains bins for residual and recycling waste materials by which the public can dispose of household waste.]

C&D- Construction and Demolition

C&I- Commercial and Industrial

CV- Calorific Value [a measure of energy content, typically quoted as Mega Joules (MJ)]

DM- Dry matter [% of a sample that is not moisture]

EfW- Energy from Waste

ETI- Energy Technology Institute

HHW- hazardous household waste [batteries, engine oil, paint etc]

HWRC- Household waste Recycling Centres [as CA]

LOI- Loss-on-ignition [% of a sample that is determined to be organic under a controlled laboratory test]

MSW- Municipal Solid Waste

RDF [refuse derived fuel]- a high calorific material obtained from the processing of mixed organic wastes. Consists largely of paper, card and plastics.

Recycling- the separation of waste materials either at source or at a bulking centre where materials are then diverted for treatment prior to reuse as a raw material commodity.

Residual wastes- typically black bag waste; what is left after recycling

SRF [solid recovered fuel]- similar to RDF except produced to a set standard and classified in terms of CV, chlorine and mercury content.

Waste composition- the percentage by weight of plastics, wood, paper, etc.

Waste arisings- the quantity [tonnes] and type of waste being produced at a given location(s) within a specified time period

WEEE- waste electronic and electrical equipment

1. Project Overview

This project, funded by the Energy Technologies Institute [ETI], is collaboration between Caterpillar [lead], EDF Energy, Cranfield University, Centre for Process Innovation [CPI] and Shanks Waste Management. The ETI is a private sector organisation, funded equally by industrial member companies and the UK Government. The project team will assess the potential energy content of waste arisings across the country, evaluate existing technologies and identify opportunities for technology development and improvements to generate energy from waste. Outputs will include a waste resource map and data obtained from rig-scale testing. This project will be providing an informed basis of where the focus should be aimed regarding technological development and research decisions based on the current UK waste arisings and the energy recovery potential of those materials.

2. Background

2.1. UK waste streams

Waste arisings across the UK are divided into classifications based on the sector from which they originate. The main waste streams are as follows:

- Municipal- typically household waste, including collected recycled and residual waste, and wastes from civic amenity [CA] sites/ household waste recycling centres [HWRCs];
- Commercial- waste collected from all commercial premises, which includes sectors such as retail, education, catering and hospitals. Recycled wastes are collected from these premises, along with residual [black bag] waste;
- Industrial- waste arising from industrial processes such as manufacturing and material processing;
- Construction and demolition- materials arising from the construction of all household, commercial and industrial premises, along with the demolition of such buildings. As expected, much of this waste stream is inert materials [i.e. rubble];
- Agricultural- materials arising from the growing of crops and the farming of animals. Also includes the fishing sector;
- Sewage- wastewater and solid sludges;
- Dredged materials- from the management and development of sea ports and harbours, including the management of flood barriers;

2.2. Requirements to understand waste arisings and composition

In order to achieve the overall objectives of the project, an understanding of the UK waste as a whole is required.

The following points illustrate the information required-

1) Tonnages of total waste arising in the UK;
2) Tonnage of each waste stream arising in the UK;
3) Tonnage and distribution of each waste stream per region in the UK;
4) Distribution of waste by industry type and location;
5) Composition of each waste stream;
6) Elemental composition of each waste component;
7) Calorific content of each waste component;
8) Seasonal variation in arisings and compositional information;

Additionally information is required on the growth rates of each waste stream, contractual information [i.e. number of tonnes committed to local authority treatment contracts] and policy drivers [for example, landfill directive, recycling targets etc].

An understanding of the above would enable a good estimation of the potential for energy recovery from the UK waste materials, what these materials consist of, how the materials perform in a number of energy recovery technologies; and the location and distribution of the potential fuels.

2.3. Sources of data

Information on the arisings, composition and location of waste materials can be obtained from a number of sources such as-

- Defra- reports (Fisher 2006; Defra 2008) and databases;
- Environment Agency- reports (Marcus Hodges Environment Ltd 2001; SEPA 2006; McLaurin, Darby et al. 2008; SEPA 2008) and databases (Environment Agency 2002);
- Local Authorities- waste analysis reports (Poll 2004) and reported data to the Waste Data Flow;
- WRAP- specific sector and waste stream reports (Parfitt 2002; Nikitas, Boulos et al. 2005; Pöyry Forest Industry Consulting Ltd and Oxford Economics Ltd 2009);
- Development agencies- waste arisings and composition (Jones, Scholes et al. 2007; Greifenberg, Smith et al. 2008; Narburgh and Martin 2008; Scholes, Areikin et al. 2009);
- Private company reports (Smith, Kersey et al. 2002; Rodger 2003; Lee, Fitzsimons et al. 2005);
- Academic publications (Parfitt and Flowerdew 1997; Ranta 2005);
- Biffaward series of publications (Biffaward 2006)

2.4. Report Objectives

The specific objectives of this report are to-

- Present the sources of existing data regarding waste arisings, composition and the energy recovery potential;
- Discuss the limitations in the existing knowledge;
- Present the methods of gaining a more complete understanding of the UK waste materials in terms of the spatial arisings, composition and potential to recover energy.

3. Methodology- Current Data

3.1. Collation of existing sources

The full bibliography is provided in Appendix A. The bibliography will be extended as new reports and publications are released, along with further sources of information recommended by leading experts in the field at the validation workshop.

3.2. Waste flow modelling

The detailed methods of collating the information required for the model, along with a discussion of the assumptions made, are provided in Volume 2 of this report.

3.3. Validation workshop

A validation workshop was hosted in October 2009 in which the collated sources of waste data were presented to a number of key experts in the waste management industry. As a result of this workshop a number of further key reports and data sources were suggested. Additionally the assumptions used in the waste models were validated.

The briefing note and output feedback note from the workshop is provided in Appendix B and C respectively.

4. Assessment of existing data

4.1. Waste arisings and Composition

Individual components of a waste material may, or may not, have the potential use as a source of energy. Table 1 gives a brief overview of the major components of waste that can potentially provide a source of energy.

Table 1. Potential energy content of waste components

Material	Potential for energy?
Paper & card	✓
Plastic film	✓
Dense plastic	✓
Textiles	✓
Wood	✓
Furniture	✓
Other combustibles	✓
Glass	×
Rubble (C&D waste)	×
Other non-combustibles	×
WEEE	Unlikely
Hazardous household	Unlikely
Kitchen	✓
Green waste	✓
Fe metal	×
Non-fe metal	×
Fines	✓

The following Tables 2-6 provide summaries of the UK waste arisings, UK MSW residual composition, the C&I arisings by waste type, the composition of mixed C&I waste and the composition of C&D waste respectively.

The assumptions for these Tables are provided in the approach to modelling [Volume 2] and the full modelling and datasets are provided in Appendix D.

Table 2. UK waste arisings ['000 tonnes]

	MSW[1]	C&I[2]	C&D	AGRICULTURAL[3]
ENGLAND	06/07.	06/07.		
North East	1,500	2,440		118
North West	3,938	7,532	10,793[4]	67
Yorkshire and Humberside	2,838	9,752		363
East Midlands	2,405	6,157		651
West Midlands	2,982	6,290		232
East	3,014	5,689	10,324[5]	495
London	3,997	7,337		18
South East	4,494	8,701		338
South West	2,859	4,760		304
TOTAL	28,027	58,658	89,600[6]	2,586
WALES	06/07.	06/07.		
TOTAL	1,785	3,573	12,167[7]	32
SCOTLAND	06/07.	06/07.		
TOTAL	2,134	8,093	11,804[8]	366
NORTHERN IRELAND	06/07.	06/07.		
Arc21	576			
NWRWMG	196			
SWAMP	282			
TOTAL	1,053	1,560	1,715[9]	28
UK TOTAL	33,000	71,884	115,286	3,012

[1] AEA models
[2] AEA models
[3] AEA models
[4] Beedell, J., C. Yates, et al. (2007). Study to fill the evidence gaps for construction, demolition and excavation waste streams in the North West region of England, Smiths Gore.
[5] Blackwell, M. (2008). East of England C&D waste arisings, BRE.
[6] Capita Symonds Ltd and WRc plc (2007). Survey of arisings and use of alternatives to primary aggregates in England, 2005: construction, demolition and excavation waste. London, Office of the Deputy Prime Minister.
[7] Environment Agency (2006). A survey on the arising and management of construction and demolition waste in Wales 2005-06. Cardiff.
[8] SEPA (2006). Construction and demolition wastes in Scotland, SEPA.
[9] Capita Symonds Ltd and WRc plc (2006). Survey of arisings and use of construction, demolition and excavation waste as aggregate in Northern Ireland in 2004/05 & 2005/06, Environment and Heritage Service.

Table 3. UK MSW waste composition [% weight]

	ENGLAND									WALES	SCOTLAND	NI
	North East	North West	Yorkshire and Humberside	East Midlands	West Midlands	East	London	South East	South West	Overall	Overall	Overall
Paper & card	18.9%	17.9%	19.7%	17.8%	17.7%	16.6%	15.8%	17.7%	15.4%	16.8%	20.0%	17.4%
Plastic film	5.9%	6.4%	6.0%	7.0%	6.2%	7.1%	5.4%	7.0%	6.6%	8.0%	4.6%	5.9%
Dense plastic	7.1%	7.6%	7.4%	8.2%	7.8%	8.3%	6.5%	8.3%	7.9%	4.8%	9.2%	6.3%
Textiles	3.7%	3.7%	3.7%	4.2%	3.8%	4.0%	3.4%	3.9%	3.9%	4.0%	3.4%	3.7%
Wood	3.8%	3.2%	3.0%	5.0%	4.7%	5.5%	5.0%	3.7%	5.3%	0.7%	5.2%	2.4%
Furniture	2.0%	1.5%	1.7%	2.3%	2.0%	2.2%	1.8%	2.3%	2.2%	2.1%	1.8%	2.0%
Other combustibles	8.0%	7.9%	8.5%	10.0%	8.7%	9.5%	7.4%	9.6%	9.2%	7.9%	7.9%	7.4%
Glass	4.3%	4.6%	4.1%	1.3%	5.0%	0.1%	3.9%	2.3%	0.6%	3.0%	5.4%	7.0%
Rubble (C&D waste)	0.1%	1.7%	1.2%	2.8%	1.5%	4.7%	3.4%	2.1%	2.0%	5.1%	0.5%	4.1%
Other non-combustibles	1.8%	2.0%	1.9%	2.2%	1.9%	2.2%	1.7%	2.1%	2.0%	2.0%	1.8%	1.8%
WEEE*	1.9%	1.7%	1.6%	1.9%	1.9%	1.9%	2.0%	1.5%	1.7%	1.5%	1.6%	1.4%
HHW[#]	0.6%	0.6%	0.6%	0.7%	0.6%	0.7%	0.5%	0.7%	0.6%	1.0%	0.1%	0.6%
Kitchen	26.2%	26.3%	27.0%	26.1%	24.2%	26.2%	24.7%	30.9%	30.0%	24.9%	27.2%	26.9%
Green waste	8.0%	6.8%	6.0%	2.8%	6.1%	3.6%	11.1%	0.9%	5.4%	11.6%	2.4%	5.6%
Fe metal	3.0%	2.9%	2.8%	2.2%	2.9%	2.1%	3.0%	1.7%	2.0%	2.3%	3.2%	2.8%
Non-fe metal	1.0%	1.1%	1.0%	1.0%	1.1%	0.9%	1.0%	0.8%	0.9%	0.9%	1.0%	1.1%
Fines	3.8%	4.1%	3.9%	4.5%	4.0%	4.5%	3.5%	4.5%	4.3%	3.4%	4.6%	3.8%

*WEEE- waste electrical and electronic equipment

[#]HHW- hazardous household waste

Table 4. C&I waste arisings by waste type ['000 tonnes]

	England	Wales	Scotland	Northern Ireland
Chemicals	7,641	127	499	42
Metallic	2,961	333	394	113
Non-metallic	12,930	866	2,286	363
Discarded equipment	424	38	90	19
Animal & plant	3,842	400	714	165
Mixed	19,974	1,134	3,503	595
Common sludges	1,914	80	113	30
Mineral wastes	8,972	595	495	233
Total	58,658	3,573	8,093	1,560

Table 5. Composition of C&I mixed waste [residual[10]] (SLR Consulting 2007)

	Composition (Wt %) of mixed waste stream
Paper and cardboard	32
Plastic film	7
Dense plastic	8
Textiles	2
Other combustibles	16
Glass	4
Other non-combustibles	6
Food/kitchen waste	13
Other organics	2
Metal	4
Household hazardous	1
WEEE	1
Fines	4
Total	**100**

[10] Residual is typical black bag waste- which is general waste. Recyclable materials are collected separately [i.e. source segregated] depending on the business type and location, therefore the residual waste is what is left following recycling.

Table 6. Composition of C&D waste (Environment Agency 2006)

	Component	Wt %
	Aggregate	48
	Soils	40
Others (12%)	Paper & Cardboard	1
	Wood	3
	Plastics	1
	Glass	0.1
	WEEE & Batteries	0.1
	Hazardous (solvents, oils, etc)	2
	Insulation & Gypsum	1
	Metals	1
	General	1
	Biodegradable	1

Whilst the understanding of C&D waste streams is comparatively limited, there has been considerable interest in the arisings of wood waste. This is a waste material that has the potential for use as a fuel with a reported net calorific [CV] of 12.1-12.3 GJ/t, which is almost double that of typical MSW (Department of Energy and Climate Change 2009). Table 7 shows the waste arisings regionally per waste stream.

Table 7. UK wood waste arisings ['000 tonnes] (Pöyry Forest Industry Consulting Ltd and Oxford Economics Ltd 2009)

	Packaging	Industrial	Construction	Demolition	Municipal	Total
East Midlands	101.8	40.3	80.8	73.9	36.1	333
East of England	121.8	48.1	96.1	135.1	46.1	447
London	123.4	48.8	180.9	158.3	23.4	534
North East	36.7	14.5	50.4	45.6	26.9	175
North West	125.3	49.5	134.2	110.9	123	543
South East	162.7	64.3	150.8	190.7	57.6	626
South West	106	41.9	96.4	101.2	69.1	414
West Midlands	126.6	50	95.1	92.8	54.8	420
Yorkshire & Humber	103.3	40.8	108.7	91.9	69.4	414
England	**1,007.6**	**398.2**	**993.4**	**1,000.4**	**506.4**	**3,906**
Wales	49.6	19.6	45.1	35	55.4	205
Scotland	76.3	30.2	107.4	87.9	28.3	329
Northern Ireland	36.4	14.4	38.6	14.2	28.6	132
United Kingdom	**1,169.9**	**462.4**	**1,184.5**	**1,137.5**	**618.7**	**4,572**

4.2. Energy Recovery Potential

The models provided in Appendix D show detailed calculations based on the availability of waste materials, and the energy potential of the materials.

Figures 1 and 2 indicate the net CV of the remaining residual waste [C&I and MSW] and the organic waste streams respectively.

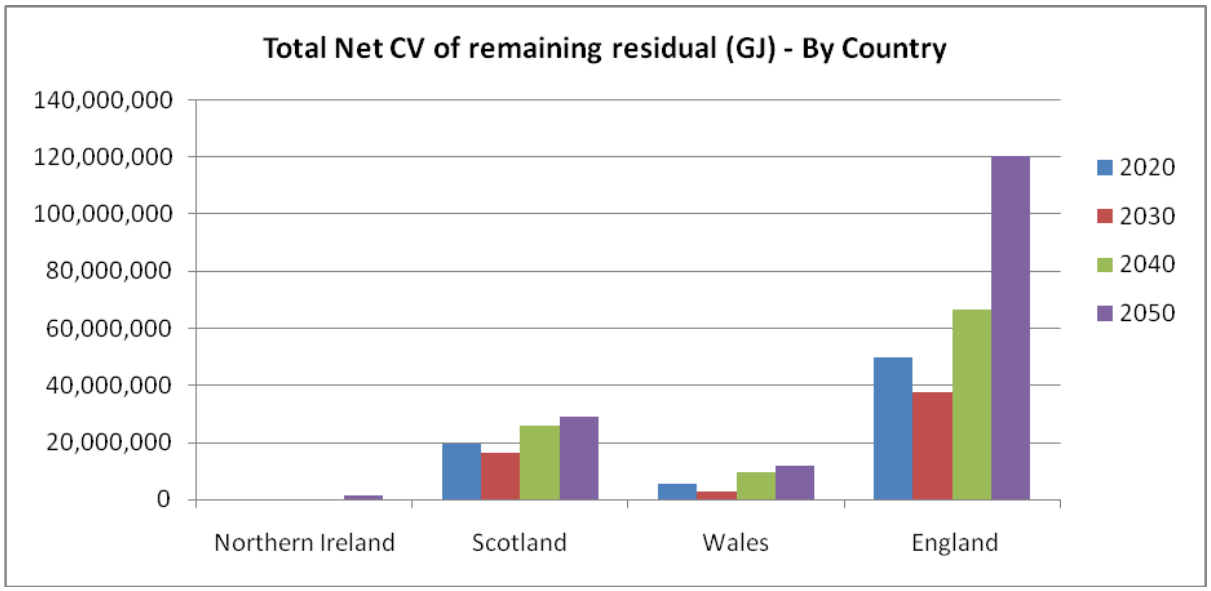

Figure 1. Net CV of available residual waste material [C&I and MSW]

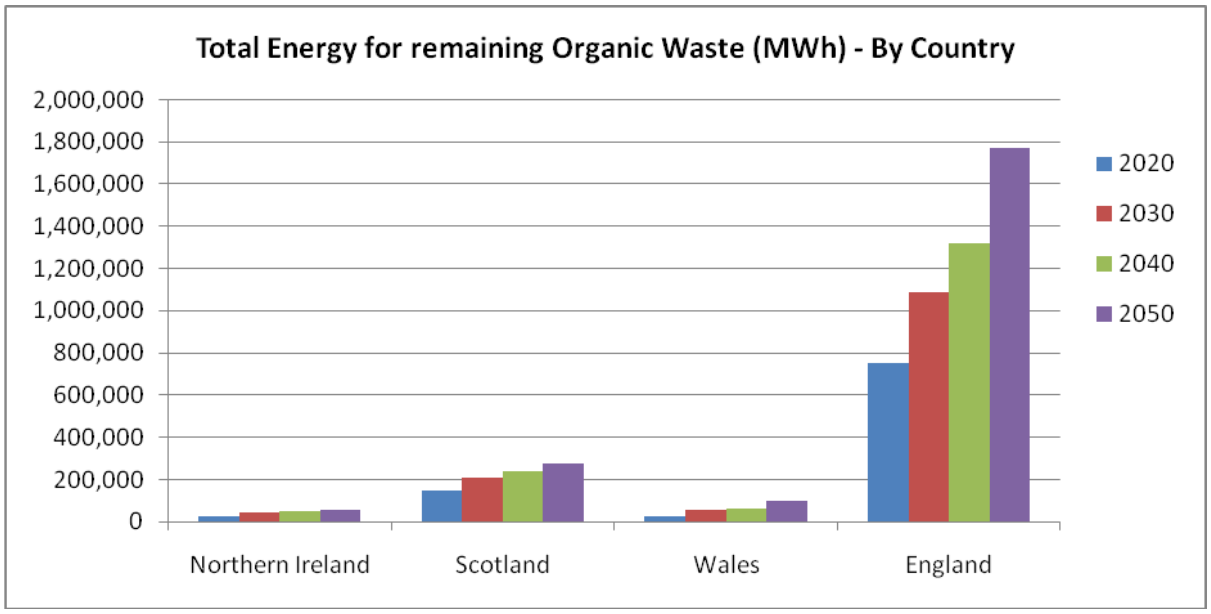

Figure 2. Total energy for the remaining organic waste fraction

Figures 1 and 2 only take into account the available waste materials- not wastes that are contractually obliged to other treatment processes. The sharp increase between 2040 and 2050 for the available material is due to the lifetime expectancy of existing and planned facilities, and thus highlights the potential for long-term investment opportunities.

The full details and discussions of the trends shown in the Figures and modelling are provided in Volume 2 of this report.

5. Waste analysis regime

5.1. Sampling benefits

Compositional data has been taken from several reports and modelled across the UK. The potential energy content of these wastes has also been modelled based on the compositional information. Whilst the compositional data for MSW is relatively widely available, this information for C&I and C&D wastes is not. Therefore the sampling regime will allow real data to be sourced on the composition of these wastes, along with comprehensive laboratory analysis. Additionally the process test plan will allow further information on the performance of waste components in different technologies.

In terms of the current and post-sampling knowledge and understanding of waste materials in work package 1, the understanding of the composition of C&I and C&D waste arisings will be greatly improved. The compositional information for MSW will be validated by the sampling. The understanding of the detailed characteristics of individual components of waste [i.e. paper, wood, plastics etc] will be further understood, however importantly these will be understood in the context of arisings and physical composition of the waste sources from which they originate. The comprehensive analysis will also provide proximate and ultimate analysis alongside CV data for all components- data which is not readily available otherwise.

The sampling and detailed waste analysis will compliment and assist in the other work packages of the overall research programme, for example the technology modelling and the development of the energy from waste maps. Finally, the sampling regime will allow the reliability of validity of existing waste data as well as test current reports and inform seasonal variation.

Table 8 summarises the current knowledge and the additional understanding that will be gained from a rigorous sampling regime involving a number of different sites dealing with varying waste materials.

The sampling regime will address requirements 5-8 as highlighted in section 2.2. The remaining data requirements will be addressed by reported data [i.e. waste data flow].

Table 8. Current understanding and post-sampling capability

	Current understanding			Post-sampling understanding		
Parameter	**MSW**	**C&I**	**C&D**	**MSW**	**C&I**	**C&D**
Composition	Yes	Yes	Yes	Yes	Yes	Yes
Calorific value	Yes	Single material values are known for specific materials, e.g. wood and plastic waste components; Missing data: there are no data for the calorific and elemental mix for complete waste streams [C&I and C&D].		Yes	Yes	Yes
Elemental content	Yes			Yes	Yes	Yes
Seasonal variation	Yes	No		Yes	Yes	Yes
COMBINED	No report provides a comprehensive summary of all the compositional information for individual waste streams, therefore with the current level of publicly available information it is unreliable and not validated to make reasonable comparisons across the UK			The sampling and analysis will combine all of the above compositional information, for individual waste components and for overall waste samples [i.e. mixed C&I]		
Regional and National context	Currently a number of recent reports enabling a good comparison of regional, national and seasonal variations	Some reports on regional and national levels, however there is no true basis for a comparison of recent data across these levels		Able to compare data obtained with existing information for reliability analysis, and for further understanding the regional, national and seasonal variations	Good basis for comparison with previously published data to gain a strong understanding of the regional and national differences, and to understand the changes in waste arisings over the past 5-10 years.	
OVERALL	Combined understanding of the compositional parameters does not allow a strong understanding of the overall energy recovery potential of these materials. A focused sampling regime would allow for a greater understanding of this in collaboration with the existing data			Overall an improved understanding of the compositional content of UK waste materials, along with an improved capability to compare collected data with existing data for a widespread, national and regional, view of energy recovery potential and the spatial and seasonal variation		

5.2. Development of sampling regime

Samples collected, or sorted on site, will need to provide a representation of the mixed waste or sorted components. These waste materials are to be taken from input and output materials at a range of waste processing sites across the UK. Samples will undergo a detailed and descriptive sort, which is described in further detail later. As part of a detailed sort, samples will be placed in a sealed container and taken off site for further analysis.

Sampling will take place over a two week period on a number of sites, and will be repeated for each of the four seasons.

The following Shanks sites will be used in each of the seasonal analyses-

- Kettering
- Elstow
- Milton Keynes
- Blochairn
- Redmoss or Broxburn

The key activities identified which will enable a sampling regime which is deliverable in the given timeframe and will provide valuable information are detailed sorts, collection of samples and descriptive sampling.

The detailed sort will proceed as follows-

- At least 4 small grabs [by mechanical and/or standard shovels] are made from the pile of input material used for the descriptive sort (below) and placed in a separate pile.
- This pile will be turned and mixed using a shovel.
- A quarter of the mix will be sectioned off and taken aside and, following further mixing and turning, another quarter of the mix will be placed in a container for further laboratory analysis.
- The first quarter will be sorted by hand into separate buckets for the individual components [paper, card, metals etc]. Each of the sorted components will then be weighed.

The sample collection is described above. In addition, fractions of waste components sorted by the waste processing site will also be extracted and stored as described.

The descriptive method is outlined below-

- A large sample of waste will be tipped onto the floor and spread across the floor [covering an area of approx 35 m^2].
- Bags of waste will be split, emptied and mixed into the waste pile.
- A quadrat [1 x 1 m] will be placed over the spread waste and a high resolution photograph will be taken from directly above.

- An estimated 30 images will be captured per waste 'pile'.
  Therefore 2 piles will be targeted per sampling day if reasonably practical.
- The area of each waste component will be accurately measured and a % w/w will be calculated.

The key objectives of the sampling and waste characterisation are to provide further information on the knowledge limitations highlighted earlier. Therefore the sampling plan has been formulated to focus mainly on the C&I waste stream, however including C&D and MSW as required.

The compositional analysis will progress as outlined in Table 9.

Table 9. Compositional analysis outline

Site	Kettering	Elstow	Milton Keynes	Blochairn	Broxburn or Redmoss
Day 1	C&D	Civic amenity [CA] residual	Mixed commercial	Mixed C&I	Mixed C&I
Day 2	C&D	Household residual	Mixed industrial	MSW residual	Mixed C&I

The current understanding of waste data was summarised in Table 8, which has formed the basis for the planning of the proposed sampling regime. Additionally the proximate and ultimate information for refuse derived fuels (RDF) and solid recovered fuel (SRF) is well understood, along with the knowledge of how these materials perform in energy recovery processes as feedstock, or as co-fired fuels.

The main focus of the compositional analysis should include C&I and C&D wastes, however the majority of the sampling involves C&I waste materials, as C&D waste streams typically involve mostly inert materials [shown in Table 6]. The waste received at the Milton Keynes site is delivered by a number of different sized collection vehicles, and for this study the waste sampled will be from all deliveries, including those by trade refuse vehicles [TRVs]. These vehicles each collect from approximately 40 different premises in the locality and so provide a good representation of typical C&I residual waste [black bag waste].

The industrial waste received by the Milton Keynes site is sent to the Kettering site for further processing, therefore only the C&D materials will be sampled at the Kettering site to avoid sample duplication.

MSW materials will vary between household collected and residual waste from CA sites, and so both have been included in the analysis plan to enable a good comparison between the collected data and the existing reports on a regional and national basis.

The samples collected will be taken from the site for the rig work [work package 2] and for third party laboratory analysis [elemental and proximate analysis- moisture content and CV], which is explained in section 5.3.

5.3. Sample collection plan

Samples will be collected from each of the sites, prepared at Cranfield University and assessed further.

5.3.1. Rig analysis samples

As described in report 2.1, a rigorous test plan has been highlighted and discussed. The samples collected as part of this study will provide the materials required for this test plan.

5.3.2. Third party laboratory analysis

The third party laboratory analysis will analyse samples taken in triplication to allow a statistically valid analysis plan.

The analysis will comprise of proximate and ultimate analysis, which includes-

- Dry matter (%DM)[11]
- Loss-on-ignition (%LOI)[12]
- Ash content[13]
- Calorific value (CV)
- Elemental (C, H, N, S, Cl and O)

The analysis will be undertaken on all samples that undergo a detailed sort, other delivered waste streams [e.g. street sweepings at Milton Keynes site], all sorted outputs [including organic fines, reject material and refuse derived fuel (RDF)] and all 'recipes' used in the process technology test plan outlined in report 2.1.

5.3.3. Health and Safety Arrangements

Arrangements with Shanks staff

A meeting was arranged at the Shanks head office in Milton Keynes with Mr Geoff Smallwood, Shanks Health and Safety Manager, and the proposed sampling methodology was discussed. All potential hazards were considered, and no major concerns were raised. It was agreed that sampling would begin each day later in the afternoon once all site vehicle movements have stopped to eliminate the risk of traffic accidents.

[11] Heating material of a known mass at 105°C over night. The difference in mass after heating is the moisture content. Results quoted as %DM (i.e. the percentage of the sample that is not moisture).

[12] Heating the dried material (from %DM analysis) of a known mass at 550°C in a furnace for 2 hours. The remaining inorganic ash is then weighed, allowing the calculation of the organic content from the original sample.

[13] Ash remaining after combustion (i.e. after LOI)

The sampling schedules, and the following H&S arrangements, have been agreed with each individual Site Manager, the H&S Manager of Shanks and the regional H&S Manager. A member of Shanks staff will be present onsite at all times during sampling, and the agreed procedures will be followed at all times.

All PPE required by the site, and PPE recommended by the Health and Safety Manager, will be worn at all times.

The allocated area for sampling will be agreed prior to arrival at the site, and the necessary arrangements in place [i.e. marquee, cones, etc].

Equipment

PPE-

- Anti-syringe gauntlets
- Disposable white overalls
- Safety boots: High leg lace-up with toe and midsole protection
- PP3 mask
- Safety glasses or similar [goggles etc]
- High visibility jacket
- Hard hat

Other-

- Shovel
- Buckets
- Sample containers
- Rake
- Scales
- Quadrat [1 x 1 m]
- Digital camera
- Sample labels

Other considerations include a marquee, which is required if working outside away from a tipping hall.

Sampling area

To be assigned for each site prior to arrival to ensure safe working, and minimal disruption to the site.

Welfare

Sign-in at site reception/weighbridge prior to commencing work, and sign out when leaving the working area. Keep H&S contact informed of any changes to work plan, and report any near-misses and incidents.

6. Summary

Existing sources of waste data have been identified, and validated by the workshop. The full list of waste data sources gathered to date is shown in Appendix A. The collection and research of existing databases and reports is an on-going process, and so further references will be added in later reports.

The waste modelling work undertaken highlights the waste arisings, potential energy content and makes reasoned assumption regarding the future trends of the available waste materials.

The key limitations in the existing data include the mixed C&I and C&D wastes. The sampling regime has been proposed to enhance the knowledge of these waste streams, whilst the ongoing collation of data from existing sources and approaching the appropriate industries [as recommended at the data validation workshop] will further develop the data. A greater understanding of these wastes will enable a better estimate of the energy recovery potential.

The proposed waste map approach will allow a spatial understanding of waste arisings, density and energy potential.

7. References

Beedell, J., C. Yates, et al. (2007). Study to fill the evidence gaps for construction, demolition and excavation waste streams in the North West region of England, Smiths Gore.

Biffaward (2006). The mass balance movement: the definitive reference for resource flows in the UK environmental economy, RSWT.

Blackwell, M. (2008). East of England C&D waste arisings, BRE.

Capita Symonds Ltd and WRc plc (2006). Survey of arisings and use of construction, demolition and excavation waste as aggregate in Northern Ireland in 2004/05 & 2005/06, Environment and Heritage Service.

Capita Symonds Ltd and WRc plc (2007). Survey of arisings and use of alternatives to primary aggregates in England, 2005: construction, demolition and excavation waste. London, Office of the Deputy Prime Minister.

Defra (2008). Wood waste as a biomass fuel, Defra.

Department of Energy and Climate Change (2009). Digest of United Kingdom energy statistics. London, National Statistics.

Environment Agency (2002). National waste production survey, Environment Agency.

Environment Agency (2006). A survey on the arising and management of construction and demolition waste in Wales 2005-06. Cardiff.

Fisher, K. (2006). Impact of energy from waste and recycling policy on UK greenhouse gas emissions, Defra.

Greifenberg, P., M. Smith, et al. (2008). Commercial and industrial waste data analysis of the North West Region, Urban Mines.

Jones, G., P. Scholes, et al. (2007). Study to fill evidence gaps for commercial & industrial waste streams in the North West region of England, Urban Mines.

Lee, P., D. Fitzsimons, et al. (2005). Quantification of the potential energy from residuals (EfR) in the UK. Renewable Power Association.;Institute of Civil Engineers, Oakdean Hollins.

Marcus Hodges Environment Ltd (2001). Towards sustainable agricultural waste management, Environment Agency.

McLaurin, I., P. Darby, et al. (2008). Estimation of commercial and industrial waste produced in Scotland in 2006, Scottish Environmental Protection Agency (SEPA).

Narburgh, M. and A. Martin (2008). Ipswich waste composition study, Bright Green [East of England] Ltd.

Nikitas, C., S. Boulos, et al. (2005). Review of wood waste arisings and management in the UK-summary report, WRAP.

Parfitt, J. (2002). Analysis of household waste composition and factors driving waste increases, WRAP, Report to the Strategy Unit**:** 31pp.

Parfitt, J. P. and R. Flowerdew (1997). "Methodological problems in the generation of household waste statistics : An analysis of the United Kingdom's National Household Waste Analysis Programme." Applied Geography **17**(3): 231-244.

Poll, J. (2004). Greater London Authority waste composition scoping study, AEA Technology.

Pöyry Forest Industry Consulting Ltd and Oxford Economics Ltd (2009). Wood waste market in the UK, WRAP.

Ranta, T. (2005). "Logging residues from regeneration fellings for biofuel productionâ€“a GIS-based availability analysis in Finland." Biomass and Bioenergy **28**(2): 171-182.

Rodger, C. (2003). Stansted Airport waste composition survey, August 2003, Network Recycling.

Scholes, P., E. Areikin, et al. (2009). Survey of industrial & commercial waste arisings in Wales, Urban Mines.

SEPA (2006). Construction and demolition wastes in Scotland, SEPA.

SEPA (2008). Waste Data Digest 8: Key facts and trends, SEPA.

SLR Consulting (2007). Determination of the Biodegradability of Mixed Industrial and Commercial Waste Landfilled in Wales.

Smith, R. A., J. R. Kersey, et al. (2002). The construction industry mass balance: resource use, wastes and emissions, Viridis.

Appendices

A. Full bibliography

1. 4sight *Rocks to rubble*; B/1127; Biffaward: 2005.
2. Alker, S.; Ravetz, J. *Spatial planning for integrated waste transport*; B/2150; EnviroCentre Ltd: 2006.
3. Allwood, J. M.; Laursen, S. E.; de Rodriguez, C. M.; Bocken, N. M. P. *Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom*; B/2222; University of Cambridge: 2006.
4. Barrett, J.; Chambers, N.; Cherrett, N.; Jenkin, N.; Lewis, K.; Vergoulas, G. *A mass balance and ecological footprint analysis of the NHS in England and Wales*; B/1635; Best Foot Forward Ltd: 2004.
5. Beedell, J.; Yates, C.; Teanby, A.; Allcock, B.; Kendal, C.; Green, S.; Godfrey, E.; Martin, J.; Vaughan, W. *Study to fill the evidence gaps for construction, demolition and excavation waste streams in the North West region of England*; Smiths Gore: 2007.
6. Best Foot Forward Ltd *City Limits: a resource flow and ecological footprint analysis of Greater London*; B/1646; Biffaward: 2002.
7. Best Foot Forward Ltd; Imperial College *Island State: an ecological footprint analysis of the Isle of Wight*; B/1303; Biffaward: 2001.
8. Biffaward *The mass balance movement: the definitive reference for resource flows in the UK environmental economy*; RSWT: 2006.
9. Blackwell, M., East of England C&D waste arisings. In BRE: 2008.
10. Bridgwater, E.; Parfitt, J. *Evaluation of the WRAP separate food waste collection trials*; WRAP: 2009.
11. British Furniture Manufacturers Ltd *Benchmarking solvent use in the UK furniture manufacturing sector*; B/1424; Biffaward: 2001.
12. British Glass Foundation *A fundamental appraisal of the environmental impact of large-scale glass manufacture*; B/1489; Biffaward: 2004.
13. Bromhead, A. *Benchmarking wood waste combustion in the UK furniture manufacturing sector*; B/1815; BFM Ltd: 2005.
14. Brook Lyndhurst Ltd *Lifestyle scenarios and waste composition*; Defra: 2007.
15. Burnley, S. J., A review of municipal solid waste composition in the United Kingdom. *Waste Management* **2007,** *27*, (10), 1274-1285.
16. Burnley, S. J., The use of chemical composition data in waste management planning - A case study. *Waste Management* **2007,** *27*, (3), 327-336.
17. Burnley, S. J.; Ellis, J. C.; Flowerdew, R.; Poll, A. J.; Prosser, H., Assessing the composition of municipal solid waste in Wales. *Resources, Conservation and Recycling* **2007,** *49*, (3), 264-283.
18. Capita Symonds Ltd; WRc plc *Survey of arisings and use of construction, demolition and excavation waste as aggregate in Northern Ireland in 2004/05 & 2005/06*; Environment and Heritage Service: 2006.
19. Capita Symonds Ltd; WRc plc *Survey of arisings and use of alternatives to primary aggregates in England, 2005: construction, demolition and excavation waste*; Office of the Deputy Prime Minister: London, 2007.
20. Chambers, N.; Child, R.; Jenkin, N.; Lewis, K.; Vergoulas, G.; Whitely, M. *A resource flow and ecological footprint analysis of the South West of England- Resource flow*; Stepping Forward; Best Foot Forward Ltd: 2005.
21. Chambers, N.; Child, R.; Jenkin, N.; Lewis, K.; Vergoulas, G.; Whitely, M. *A resource flow and ecological footprint analysis of the South West of England- Scenarios report*; Stepping Forward; Best Foot Forward Ltd: 2005.

22. Chambers, N.; Child, R.; Jenkin, N.; Lewis, K.; Vergoulas, G.; Whitely, M. *A resource flow and ecological footprint analysis of the South West of England- Summary report*; Stepping Forward; Best Foot Forward Ltd: 2005.
23. Chambers, N.; Child, R.; Jenkin, N.; Lewis, K.; Vergoulas, G.; Whitely, M. *A resource flow and ecological footprint analysis of the South West of England- Technical report*; Stepping Forward; Best Foot Forward Ltd: 2005.
24. Chambers, N.; Griffiths, P.; Lewis, K.; Jenkin, N. *Scotland's footprint: a resource flow and ecological footprint analysis of Scotland*; B/1831; Best Foot Forward Ltd: 2004.
25. Chang, N.-B.; Wang, H. P.; Huang, W. L.; Lin, K. S., The assessment of reuse potential for municipal solid waste and refuse-derived fuel incineration ashes. *Resources, Conservation and Recycling* **1999,** *25*, (3-4), 255-270.
26. C-Tech Innovation Ltd *Agricultural waste mass balance: opportunities for recycling and producing energy from waste technologies*; B/1597; Biffaward: 2002.
27. C-Tech Innovation Ltd *Thermal methods of municipal waste treatment*; Biffaward: 2003.
28. C-Tech Innovation Ltd *The electricity generation mass balance*; B/2043; Biffaward: 2003.
29. C-Tech Innovation Ltd *United Kingdom food and drink processing mass balance*; B/2182; Biffaward: 2004.
30. Curry, R.; Gribble, N.; Ravetz, J.; Darlow, T.; Besch, J.; Parkinson, M. *Sustainable transport resources and waste*; B/2150; EnviroCentre Ltd: 2006.
31. Curry, R.; McDaid, C.; Chambers, N.; Lewis, K.; Simmons, C.; Vergoulas, G.; Walsh, P. *Northern Limits: a resource flow analysis and ecological footprint for Northern Ireland*; B/1946; Biffaward: 2004.
32. Dahlström, K.; Ekins, P.; He, J.; Davis, J.; Clift, R. *Iron, steel and aluminium in the UK: material flows and their economic dimensions*; B/1705; Biffaward: 2004.
33. Dalgleish, B. *Commercial and industrial waste study for the London Development Agency*; Turner & Townsend: London Development Agency, 2009.
34. Defra *Wood waste as a biomass fuel*; Defra: 2008.
35. Demirbas, A.; Gullu, D.; Caglar, A.; Akdeniz, F., Estimation of calorific values of fuels from lignocellulosics. *Energy Sources* **1997,** *19*, (8), 765-770.
36. Department of Energy and Climate Change, *Digest of United Kingdom energy statistics*. National Statistics: London, 2009.
37. Donohoe, J. *The foundry mass balance project*; B/1584; Biffaward: 2002.
38. E4Tech *Review of technologies for gasification of biomass and wastes*; 09/008; National Non-Food Crop Centre: 2009.
39. Ecological Budget UK *Counting consumption: CO2 emissions, material flows and Ecological Footprint of the UK by region and devolved country*; B/2230; WWF: 2006.
40. Elghali, L.; McColl-Grubb, V.; Schiavi, I.; Griffiths, P. *Sustainable resource use in the motor industry: a mass balance approach*; B/1663; Viridis: 2004.
41. Environment Agency *National waste production survey*; Environment Agency: 2002.
42. Environment Agency *A survey on the arising and management of construction and demolition waste in Wales 2005-06*; Cardiff, 2006.
43. Enviros Consulting Ltd *Sectoral mass balance study for the UK chemical industry*; B/1601; Biffaward: 2002.
44. Enviros Consulting Ltd *Sectoral mass balance study for the UK ceramics industry*; B/1505; Biffaward: 2004.
45. Fawcett, T.; Hurst, A.; Boardman, B. *Carbon UK*; B/1355; University of Oxford: 2002.
46. Fisher, K. *Impact of energy from waste and recycling policy on UK greenhouse gas emissions*; Defra: 2006.
47. Forum for the Future *Mainstreaming mass balance on farms and in universities*; B/2125; Biffaward: 2005.
48. Friends of the Earth *Commercial and industrial wastes briefing note*; 2003.

49. Greifenberg, P.; Smith, M.; Clayton, D. *Commercial and industrial waste data analysis of the North West Region*; Urban Mines: 2008.
50. Harris, A.; Sellwood, M.; Morrin, S. *Wiltshire waste partnership- residual waste composition analysis (calorific value)*; Annual Report; Entec UK: 2007.
51. Hird, A. B.; Griffiths, P. J.; Smith, R. A. *Tyre waste and resource management: a mass balance approach*; B/1352; Viridis: 2002.
52. Horticulture Research International *Mass balance model of Nitrogen flows in the UK*; B/1445; Biffaward: 2005.
53. Jones, G.; Scholes, P.; Smith, M. *Study to fill evidence gaps for commercial & industrial waste streams in the North West region of England*; Urban Mines: 2007.
54. Lazarus, N. *Construction materials report toolkit for carbon neutral developments- part 1*; B/1640; Biffaward: 2002.
55. Leach, B.; Curry, R.; Baskin, A. *Industrial and Commercial Waste Arisings Survey for Northern Ireland*; 5129.00/Report; Kirk McClure Morton: 2001.
56. Lee, P.; Fitzsimons, D.; Parker, D. *Quantification of the potential energy from residuals (EfR) in the UK*; Oakdean Hollins: Renewable Power Association.;Institute of Civil Engineers, 2005.
57. Marcus Hodges Environment Ltd *Towards sustainable agricultural waste management*; B/1265; Environment Agency: 2001.
58. McLaurin, I.; Darby, P.; Raeside, R. *Estimation of commercial and industrial waste produced in Scotland in 2006*; Final Report; Scottish Environmental Protection Agency (SEPA): 2008.
59. Meilmann, D.; Smith, H.; Stevens, G. *Meeting producer responsibility obligations: resource management and compliance reporting*; B/1425; Biffaward: 2006.
60. Narburgh, M.; Martin, A. *Ipswich waste composition study*; Final Report; Bright Green [East of England] Ltd: 2008.
61. National Society for Clean Air and Environmental Protection *Biogas as a road transport fuel*; NSCA: 2006.
62. Nikitas, C.; Boulos, S.; Shokar, P.; Leach, B. *Review of wood waste arisings and management in the UK- summary report*; 1-84405-201-X; WRAP: 2005.
63. Ogden, S. *Commercial & Industrial waste in the Yorkshire and Humber region*; 204/23; Save Waste and Prosper Ltd: 2005.
64. Parfitt, J. *Analysis of household waste composition and factors driving waste increases*; WRAP, Report to the Strategy Unit: December 2002, 2002; p 31pp.
65. Parfitt, J. P.; Flowerdew, R., Methodological problems in the generation of household waste statistics: An analysis of the United Kingdom's National Household Waste Analysis Programme. *Applied Geography* **1997,** *17*, (3), 231-244.
66. Parkinson, M.; Visco, C. *Sustainable markets for waste glass from fluorescent tubes and lamps*; B/1448; Biffaward: 2002.
67. Pira International; University of Leeds; University of Sheffield *Mass flow analysis of packaging in the UK*; B/1271; Biffaward: 2001.
68. Poll, J. *Greater London Authority waste composition scoping study*; AEAT/ENV/R/1826; AEA Technology: 2004.
69. Pöyry Forest Industry Consulting Ltd; Oxford Economics Ltd *Wood waste market in the UK*; MKN022; WRAP: 2009.
70. RACEnvironment Ltd *Mass balance of the UK pig industry*; B/2034; Biffaward: 2005.
71. RACEnvironment Ltd *Mass balance of the UK poultry industry*; B/1639; Biffaward: 2005.
72. Ranta, T., Logging residues from regeneration fellings for biofuel production: a GIS-based availability analysis in Finland. *Biomass and Bioenergy* **2005,** *28*, (2), 171-182.
73. Ravetz, J.; Barrett, J.; Wiedman, T.; Minx, J.; Moore, A.; Green, N.; Lawson, N.; Ridal, J.; Connor, S.; Brook, T. *Eco-NW: towards a one planet region*; B/1781; Biffaward: 2005.
74. Rodger, C. *Stansted Airport waste composition survey, August 2003*; BAA/03/02; Network Recycling: 2003.

75. Scholes, P.; Areikin, E.; Davey, A. *Survey of industrial & commercial waste arisings in Wales*; Urban Mines: 2009.
76. Seeda *Taking stock: an ecological footprint of the South East region*; B/1699; Biffaward: 2004.
77. SEPA *Construction and demolition wastes in Scotland*; C&D Waste Data; SEPA: 2006.
78. SEPA *Waste Data Digest 8: Key facts and trends*; SEPA: 2008.
79. SEXI *A waste focused first step towards sustainable development by the UK's exhibition industry*; B/1634; Biffaward: 2002.
80. SLR Consulting *Determination of the Biodegradability of Mixed Industrial and Commercial Waste Landfilled in Wales*; 2007.
81. Smith, R. A.; Kersey, J. R.; Griffiths, P. J. *The construction industry mass balance: resource use, wastes and emissions*; B/1406; Viridis: 2002.
82. South West England Environmental Trust *Mass balance study for the UK paper and board industry*; B/1412; Biffaward: 2003.
83. Stockholm Environment Institute *Reducing Wales' ecological footprint*; B/2011; Biffaward: 2004.
84. Sturges, M.; Brink, J. M.; Freer, E. *Mass balance of the UK magazine publishing sector*; B/1776; Biffaward: 2005.
85. The Furniture Industry Environment Trust *Packaging optimisation in the furniture sector*; B/1410; Biffaward: 2001.
86. Trada Technology Ltd *Sustainable timber waste*; B/1411; Biffaward: 2002.
87. Trada Technology Ltd *Wood: the UK mass balance and efficiency of use*; B/2173; Biffaward: 2005.
88. Tucker, P.; Douglas, P.; Polson, J. *Mass balance of UK newspapers*; B/1837; Biffaward: 2004.
89. Valpak Consultancy *Local Authorities plastic collection survey 2008*; MDP008; WRAP: 2008.
90. Voivontas, D.; Assimacopoulos, D.; Koukios, E. G., Aessessment of biomass potential for power production: a GIS based method. *Biomass and Bioenergy* **2001,** *20*, (2), 101-112.
91. Waste Watch *Analysis of public sector resource use*; B/1524; Biffaward: 2003.
92. Waste Watch *Rethinking waste management to reap rewards minimising waste for business benefit*; B/1536; Biffaward: 2004.
93. Waste Watch *Resource management in the education sector*; B/2068; Biffaward: 2005.

Databases/Other

Waste Data Flow

Phyllis

BEAT2

WasteTool- Building Waste Management

National Household Waste Survey

BIS- Statistics by Energy Source (archive)- http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk//energy/statistics/source/index.html

AEA models developed for previous work and developed for this work programme

Future Reports

Municipal waste composition: A review of municipal waste component analyses- Defra Project WR0119

Scotland municipal waste composition- final report expected March 2010

B. Workshop briefing note

Energy from Waste – UK Waste Data Validation Workshop

1. Introduction to the project

This is a project, funded by the Energy Technologies Institute [ETI], with a collaboration involving Caterpillar [lead], EDF Energy, Cranfield University, Centre for Process Innovation [CPI] and Shanks Waste Management. The ETI is a private sector organisation, funded equally by industrial member companies and the UK Government. The project team will assess the energy content of waste created across the country, evaluate the existing technologies and identify improvements to generate energy from waste. Outputs will include an energy recovery potential map [based on the UK arisings and the data from analysis] and data obtained from rig-scale testing. Providing an informed basis of where the focus should be aimed regarding technological development and research decisions based on the current UK waste arisings and the energy recovery potential of those materials.

2. About the ETI

The Energy Technologies Institute is a UK based company formed from global industries and the UK government. The ETI is an innovative and unique Limited Liability Partnership between international industrial companies with a strong focus on energy, and the UK government. Working together, sharing expertise and resources to speed up the development and demonstration of energy technologies and shorten the lead times to market.

The current private sector members of the ETI include-

- BP
- Caterpillar
- EDF Energy
- E.ON
- Rolls Royce
- Shell

The public sector members of the ETI are-

- Department of Energy and Climate Change [DECC]
- Department for Transport [DfT]
- Department for Business, Innovation and Skills [BIS]
- Engineering and Physical Sciences Research Council [EPSRC]

3. Workshop objectives

The objectives of this workshop are to-

- Review the presented data sources
- Discuss further data sources if applicable
- Review data collection approach presented
- Discuss ways in which the consortium can ensure a highly beneficial understanding of the UK waste streams is developed

The workshop is not intended to discuss individual reports, rather to discuss the data sources required to meet the overall objectives of the ETI project. As such, the focus of the day is on the aims of the overall project, and ensuring that these aims can be achieved by the methods and data sources presented.

4. Format for the day

The day will consist of introductory presentations by Cranfield University, who are leading the work package, which will provide information regarding the current knowledge of data sources, along with a methodology to collect further data. The workshop attendees will be divided into allocated working groups, who will be given small discussion tasks as defined in the agenda. This will lead to an open discussion between the facilitators and the attendees, which will form the basis of a validation of the presented information.

5. Data sources

The data sources will be presented in further detail on the day but include Defra, Environment Agency, Local Authority, public domain databases, academic journals and individual company and/or sector reports.

6. Information required from existing sources and waste collection:

A distribution of the following key facts can be obtained from the compilation of existing data sources-

- Tonnages for each waste stream in the UK
- Regional waste arisings
- Compositional information on all waste streams
- Proximate analysis (i.e. dry matter, DM) data
- Elemental content (e.g. % Carbon)

In addition to waste specific information, databases on the size, location and activities of commercial and industrial premises exist (Business Universe SIC codes).

7. Further collaborations and considerations

Attending delegates will be provided with a summary of the information collected from the public domain.

Following the workshop the consortium will be continuing to collect further information, and will provide regular updates on the information collected. We would also welcome ongoing correspondence from the attendees with regards to potential data exchange and joint developments which would provide mutual benefits to all involved.

C. Workshop outcomes (feedback note)

Energy from Waste – UK Waste Data Validation Workshop

1. Background to the project

This is a project, funded by the Energy Technologies Institute [ETI], with a collaboration involving Caterpillar [lead], EDF Energy, Cranfield University, Centre for Process Innovation [CPI] and Shanks Waste Management. The ETI is a private sector organisation, funded equally by industrial member companies and the UK Government. The project team will assess the energy content of waste created across the country, evaluate the existing technologies and identify improvements to generate energy from waste. Outputs will include an energy recovery potential map [based on the UK arisings and the data from analysis] and data obtained from rig-scale testing. Providing an informed basis of where the focus should be aimed regarding technological development and research decisions based on the current UK waste arisings and the energy recovery potential of those materials.

2. Workshop objectives

The objectives of the workshop were to-

- Review the presented data sources
- Discuss further data sources if applicable
- Review data collection approach presented
- Discuss ways in which the consortium can ensure a highly beneficial understanding of the UK waste streams is developed

3. Information required from existing sources and waste collection:

A distribution of the following key facts can be obtained from the compilation of existing data sources-

- Tonnages for each waste stream in the UK
- Regional waste arisings
- Compositional information on all waste streams
- Proximate analysis (i.e. dry matter, DM) data
- Elemental content (e.g. % Carbon)

In addition to waste specific information, databases on the size, location and activities of commercial and industrial premises exist (Business Universe SIC codes).

4. Workshop outcomes

The workshop was divided into two working group sessions. The summaries of outcomes from each session are as follows.

Session 1- waste data sources

Other professional bodies	Other consulting reports – Jupiter	Wastenet and Defra research projects
Scotland and Wales MSW	West Midlands RDA – method for co-located EfW plants (support tool)	Other Universities (background reports)
SITA library	CIWM library	Surrey University – producer responsibility
Software tool – reference Biffa	All packaging regulations – compliance	Chilled foods – CFA
IGD – grocers	Representation of Northern Ireland	WRAP – completed C&I for hospitality (compositional?)
WRAP – C&D study (early stages)	FERA– agricultural residences	Plastics and paper industries trade federation
Chemical and process industries	CIRIA/BRE	CYLCH – community recycling network
FIRA – furniture	EA Wales reports – 2009	ADAS reports – C&I 2009
ARUP – GIS map, RENEW	Defra review – MSW surveys 2007/2009	Food Forum – East of England [~2007]
NE C&I food waste survey (NISP) [~2008]	One NE – estimates of biomass [brewery waste]	WRAP – waste wood NE England [WRAP website]
Welsh MSW – AEA report – March 2010	SLR mixed C&I composition 2007	Contact trade associations
Remade association/network – urban mines	Biomass studies, e.g. waste wood, brewery solids [Northwoods/WRAP/ONE NE]	IMECHE Energy from Waste – A wasted opportunity 2008
North East England public sector food waste study	Hampshire County Council C&I – Composition/Arisings	Northern Ireland C&I composition study
Figures on SIC codes	RDA plans	

Session 2- data collection, modelling and assumptions

In this session a number of specific questions were asked, so the outcomes have been summarised for each question.

a. Is there a difference between rural and urban waste composition?

The consensus was that there will be no real difference between rural and urban in terms of composition. However, there will be differences in MSW and C&I waste arisings due to the density and population differences.

A difference would also be noticed between C&I sectors (i.e. SIC codes), as for example, certain sectors are more concentrated in urban areas.

b. Source-segregated food waste collections are likely to increase. All local authorities in Wales will implement food waste collections, but what ratios should we assume for England, Scotland and NI?

The combined views of the working groups were that the following would act as drivers for increased uptake of source-segregated collections:

- Landfill bans – affects/drives source-segregated food waste collections
- Push for AD
- Energy demand perspective
- Policy perspective – separate collection or not?
- Demand driven– economic diversion/ preferable collection routes for economic disposal

c. What ratio of in-vessel composting (IVC) and anaerobic digestion (AD) should we assume in the future?

This relates directly to the previous question- and the question still remains on how many authorities are likely to introduce separate food waste collection.

This would be economically, and politically, driven. The overall agreement was that there would be a shift towards AD, with the development of new IVCs to decrease and new ADs to increase.

d. Are the growth rates presented suitable?

A number of sources were presented which enable suitable validation against the presented forecasts.

- Could we learn from Europe?

- Volumes
- Technology
- Growth/population
- Policy

In summary, the growth rates presented seemed acceptable and suitable for the modelling.

However consideration should be given to the population growth rates, and also consumer behaviours, for example, supermarket 'buy one get one free' idealisms.

The suggested growth rates were-

Waste stream	Growth rate in base model	Sensitivity analysis
MSW	0%	-1% and +1%
Commercial	+1%	0% and +2%
Industrial	-0.5%	-1% and 0%
Agricultural waste	0%	-1% and +1%

e. What to assume for future treatment capacity?

This is very much driven by legislation, policies and economics. The rate of landfill closures will have a clear influence, but also the increasing cost of disposal at landfill (price driver/revenue loss). Also supply chain pressure, for example, retailers looking at carbon foot printing.

Also to consider that merchant facilities (especially autoclave) are targeting commercial and industrial waste streams. And that there may be a 'rush' to construct and commission facilities in the approach of EU landfill directive or LATS target years.

Contacting the Waste Infrastructure Development Programme (WIDP) was suggested.

f. Is the 70% recycling rate for the UK a reasonable assumption for the future?

The general consensus was that this assumption is acceptable. Views were divided on that it may be too high, or too low, but on the whole it was agreed that it was a fair assumption to make.

- Recycling rate – driven by CHP – trade off
- Local uncertainty – regional aggregation
- Recycling scope limited by proposed range versus future energy value
- Carbon recycling/ resource efficiency focus

It was suggested to keep to 70% recycling as Wales and Scotland already set the target within their strategies for 2025, but maybe to carry out some sensitivity analysis on recycling levels.

5. Summary and future work

The views of all workshop attendees have been collated, and further feedback has been collected post-workshop.

The suggested data sources will be pursued throughout the course of the project and used to achieve the overall aims of the ETI project.

The modelling assumptions will be considered to produce the best possible model of future forecasts with the available current knowledge.

Further discussions with workshop attendees will be sought to maintain a good level of communication and to keep all attendees informed of the developments from the ETI project.

6. Contacts

Dr Stuart Wagland
Tel. 01234 750111 ext. 2404
s.t.wagland@cranfield.ac.uk

Dr Phil Longhurst (work package leader)
Tel. 01234 754953
p.j.longhurst@cranfield.ac.uk

D. Waste flow models

E. AEA Technology Report- Executive Summary

Full report in Vol. 2.

This project was funded by the Energy Technology Institute (ETI)[14], and was delivered by a consortium involving Caterpillar UK Ltd. (lead organisation), EDF Energy Ltd, Cranfield University, Centre for Process Innovation (CPI) and Shanks Waste Management. The ETI is a private sector organisation, funded equally by industrial member companies and the UK Government.

The ETI launched this study in October 2009 to assess the waste produced in the UK and to address the need for the next generation of enhanced Energy from Waste (EfW) technologies in each UK region.[15] The project was designed to determine specifically the need for fuel flexible power systems capable of operating on a range of waste materials and streams. It characterised and mapped the UK waste landscape and identified technology development opportunities for Energy from Waste technologies in order to inform the ongoing strategic development of the ETI's Distributed Energy (DE) programme.[16]

The overall project for the ETI was divided into four Work Packages with the completion of the whole project scheduled for early 2011. This study forms part of Work Package 1, 'Waste Assessment'. The aim of this work package was to deliver a statistically representative view of the UK waste arisings, using existing data wherever possible and identifying representative waste streams with supporting chemical analysis.

AEA was appointed to develop the waste flow model and to collate all existing data relating to the target waste streams. The model outputs were intended to assess the UK's EfW requirements of the future (up to 2050), by analysing existing waste arisings and composition data and by applying a set of agreed principles and assumptions to these data sets. Waste types modelled included MSW, Commercial and Industrial (C&I), agricultural, and wood.

This report details the drivers, and key policies within the European Union and UK, directing the waste industry at present. Further to this, the report discusses the creation fo the model, the assumptions used and the data derived from the statistical analysis undertaken.

From the modelled waste types and quantities available, the fuel potential was then calculated. The results showed there would be significant amounts of waste available as a potential fuel source for EfW treatment. In 2050 the model predicts that there will be approximately 27.5 million tonnes of available material with fuel a fuel potential of 220 million GJ, this is broken down as follows:

[14] http://www.energytechnologies.co.uk

[15] http://www.letsrecycle.com/do/ecco.py/view_item?listid=37&listcatid=217&listitemid=53563

[16] http://www.energytechnologies.co.uk/Home/Technology-Programmes/Distributed-Energy.aspx

Material	Tonnes available	Energy potential (GJ)
Biowaste	12 million	2.2 million
Agricultural	3 million	54 million
RDF	-1.5 million	0
Residual MSW	14 million	164 million

The model also enables snapshots by year or by region, which will be valuable in underpinning future investment decisions about merchant facilities. Availability varies significantly between regions and also the time period when material is most available. The regions with the greatest availability of fuel potential waste remaining were in Scotland, London and the South East, for residual MSW, biowaste and RDF/SRF materials. :

However, it must be remembered that the model is based on current data sets and a number of critical assumptions. Some of these assumptions were tested for sensitivity and the analysis suggests that agreed variations in key assumptions are acceptable and would not undermine the modelling completed to date. Continual updates of the data and the assumptions will be vital in ensuring that any future decision-making is base don the most robust evidence base.